

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

KLIUKIN, Viacheslav, A.
Prechistensky Pereulok 14, build. 1
4 th Floor
Moscow 119034
FEDERATION DE RUSSIE

PCT

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL PRELIMINARY
EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing (day/month/year)	08.02.2001
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Applicant's or agent's file reference MO8881565WO	IMPORTANT NOTIFICATION	
International application No. PCT/RU98/00353	International filing date (day/month/year) 30/10/1998	Priority date (day/month/year) 30/10/1998
Applicant NORTHERN TELECOM LIMITED et al.		

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/ European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Le Nadan, M Tel. +49 89 2399-2350
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PATENT COOPERATION TREATY

9/830690

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING
OF A CHANGE(PCT Rule 92bis.1 and
Administrative Instructions, Section 422)

To:	KLJUKIN, Vyacheslav Alexandrovich Prechistensky per. 14-1 1-y etazh Moscow 119034 FÉDÉRATION DE RUSSIE
RECEIVED PCT 800 MAIL ROOM JAN 14 2002	

Date of mailing (day/month/year) 12 novembre 2001 (12.11.01)
Applicant's or agent's file reference
International application No. PCT/RU98/00353

IMPORTANT NOTIFICATION

International filing date (day/month/year)
30 octobre 1998 (30.10.98)

1. The following indications appeared on record concerning: <input checked="" type="checkbox"/> the applicant <input type="checkbox"/> the inventor <input type="checkbox"/> the agent <input type="checkbox"/> the common representative										
Name and Address NORTHERN TELECOM LIMITED Station A P.O. Box 6123 Montreal, Quebec H3C 3J5 Canada		State of Nationality CA	State of Residence CA							
		Telephone No.								
		Facsimile No.								
		Teleprinter No.								
2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning: <input type="checkbox"/> the person <input checked="" type="checkbox"/> the name <input type="checkbox"/> the address <input type="checkbox"/> the nationality <input type="checkbox"/> the residence										
Name and Address NORTEL NETWORKS LIMITED Station A P.O. Box 6123 Montreal, Quebec H3C 3J5 Canada		State of Nationality CA	State of Residence CA							
		Telephone No.								
		Facsimile No.								
		Teleprinter No.								
3. Further observations, if necessary:										
4. A copy of this notification has been sent to: <table> <tr> <td><input checked="" type="checkbox"/> the receiving Office</td> <td><input type="checkbox"/> the designated Offices concerned</td> </tr> <tr> <td><input type="checkbox"/> the International Searching Authority</td> <td><input checked="" type="checkbox"/> the elected Offices concerned</td> </tr> <tr> <td><input type="checkbox"/> the International Preliminary Examining Authority</td> <td><input type="checkbox"/> other:</td> </tr> </table>					<input checked="" type="checkbox"/> the receiving Office	<input type="checkbox"/> the designated Offices concerned	<input type="checkbox"/> the International Searching Authority	<input checked="" type="checkbox"/> the elected Offices concerned	<input type="checkbox"/> the International Preliminary Examining Authority	<input type="checkbox"/> other:
<input checked="" type="checkbox"/> the receiving Office	<input type="checkbox"/> the designated Offices concerned									
<input type="checkbox"/> the International Searching Authority	<input checked="" type="checkbox"/> the elected Offices concerned									
<input type="checkbox"/> the International Preliminary Examining Authority	<input type="checkbox"/> other:									

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Beatriz LARGO Telephone No.: (41-22) 338.83.38
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PATENT COOPERATION TREATY

PCT

From the INTERNATIONAL BUREAU

To:

KLIUKIN, Viacheslav Aleksandrovich
 Prechistensky per. 14
 Bldg. 1
 4th floor
 Moscow 119034
 FÉDÉRATION DE RUSSIE

Date of mailing (day/month/year) 06 July 2000 (06.07.00)
Applicant's or agent's file reference
International application No. PCT/RU98/00353

IMPORTANT NOTIFICATION

International filing date (day/month/year)
30 October 1998 (30.10.98)

1. The following indications appeared on record concerning: <input type="checkbox"/> the applicant <input type="checkbox"/> the inventor <input checked="" type="checkbox"/> the agent <input type="checkbox"/> the common representative				
Name and Address KLJUKIN, Vyacheslav Aleksandrovich B.Palashevsky Pereulok, 3 Moscow, 103104 Russian Federation	State of Nationality		State of Residence	
	Telephone No. (7502) 221 3008			
	Facsimile No. (7502) 221 3187			
	Teleprinter No.			
2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning: <input type="checkbox"/> the person <input type="checkbox"/> the name <input checked="" type="checkbox"/> the address <input type="checkbox"/> the nationality <input type="checkbox"/> the residence				
Name and Address KLJUKIN, Viacheslav Aleksandrovich Prechistensky per. 14 Bldg. 1 4th floor Moscow 119034 Russian Federation	State of Nationality		State of Residence	
	Telephone No. (7501) 787 2070			
	Facsimile No. (7501) 787 2071			
	Teleprinter No.			
3. Further observations, if necessary:				
4. A copy of this notification has been sent to: <input checked="" type="checkbox"/> the receiving Office <input type="checkbox"/> the designated Offices concerned <input type="checkbox"/> the International Searching Authority <input checked="" type="checkbox"/> the elected Offices concerned <input checked="" type="checkbox"/> the International Preliminary Examining Authority <input type="checkbox"/> other:				

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer A. Karkachi Telephone No.: (41-22) 338.83.38
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PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

From the INTERNATIONAL BUREAU

To:

Assistant Commissioner for Patents
United States Patent and Trademark
Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 06 July 2000 (06.07.00)	in its capacity as elected Office
International application No. PCT/RU98/00353	Applicant's or agent's file reference
International filing date (day/month/year) 30 October 1998 (30.10.98)	Priority date (day/month/year)
Applicant LEONG, Michael et al	

1. The designated Office is hereby notified of its election made:

in the demand filed with the International Preliminary Examining Authority on:

03 May 2000 (03.05.00)

in a notice effecting later election filed with the International Bureau on:

2. The election was

was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

<p>The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland</p> <p>Facsimile No.: (41-22) 740.14.35</p>	<p>Authorized officer</p> <p>A. Karkachi</p> <p>Telephone No.: (41-22) 338.83.38</p>
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PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference MO8881565WO	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/RU98/00353	International filing date (day/month/year) 30/10/1998	Priority date (day/month/year) 30/10/1998
International Patent Classification (IPC) or national classification and IPC H04M1/00		
<p>Applicant NORTHERN TELECOM LIMITED et al.</p>		
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 10 sheets, including this cover sheet.</p> <p><input type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of sheets.</p>		
<p>3. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"> I <input checked="" type="checkbox"/> Basis of the report II <input type="checkbox"/> Priority III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability IV <input type="checkbox"/> Lack of unity of invention V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement VI <input type="checkbox"/> Certain documents cited VII <input checked="" type="checkbox"/> Certain defects in the international application VIII <input checked="" type="checkbox"/> Certain observations on the international application 		

Date of submission of the demand 03/05/2000	Date of completion of this report 08.02.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Banerjea, R Telephone No. +49 89 2399 7467



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/RU98/00353

I. Basis of the report

1. This report has been drawn on the basis of (substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).):

Description, pages:

1-58 as originally filed

Claims, No.:

1-33 as originally filed

Drawings, sheets:

1/15-15/15 as originally filed

2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- the language of publication of the international application (under Rule 48.3(b)).
- the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- contained in the international application in written form.
- filed together with the international application in computer readable form.
- furnished subsequently to this Authority in written form.
- furnished subsequently to this Authority in computer readable form.
- The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- the description, pages:
- the claims, Nos.:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/RU98/00353

the drawings, sheets:

5. This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims 2-5, 7-10, 12-13, 15-27, 29-30, 32-33
	No:	Claims 1, 6, 11, 14, 28, 31
Inventive step (IS)	Yes:	Claims 17-27
	No:	Claims 1-16, 28-33
Industrial applicability (IA)	Yes:	Claims 1-33
	No:	Claims

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/RU98/00353

A. Citations and explanations in respect of paragraph V:

Reference is made to the following document:

D1: US-A-5 023 906

1. Claims 1 to 16, 28 to 33:

1.1 Document **D1** (see in particular col. 1, lines 49-53; col. 1, lines 65-68; col. 2, lines 27-39; col. 3, lines 9-11; col. 3, lines 62-66; col. 7, lines 19-25; col. 10, lines 9-15; col. 11, lines 8-10; col. 11, lines 50-68; col. 12, lines 18-20; col. 21, lines 62-68; Fig. 1) discloses, according to **all** the features of **claim 1**, an apparatus for performing cadence detection on a signal (see col. 1, lines 49-53), said apparatus comprising an input (see "15" in Fig. 1) for receiving an input signal potentially manifesting a certain cadence (see col. 7, lines 19-21), a signal processing functional block (see "10" in Fig. 1) coupled to said input for receiving the input signal, said signal processing functional block being operative to successively compute confidence level values over time during a processing period, a currently computed confidence level value being indicative of a likelihood of existence of a certain cadence in the input signal since a beginning of said processing period (see col. 1, lines 65-68; col. 2, lines 27-39; col. 3, lines 9-11; col. 7, lines 22-25; col. 11, lines 8-10; col. 11, lines 50-57), said processing period being characterised by a variable duration (see col. 3, lines 62-66; col. 21, lines 62-68), said signal processing functional block including an output for generating an output signal indicative of the confidence level value at the end of said processing period (see col. 2, lines 27-39; col. 10, lines 9-15; col. 11, lines 58-68; col. 12, lines 18-20).

The subject-matter of claim 1 therefore is not new, Article 33(2) PCT.

It should furthermore be noted that even if novelty of claim 1 could be argued, based on minor differences between the features of said claim and those disclosed in document D1, the subject-matter of claim 1 would not involve an inventive step, Article 33(3) PCT, having regard to the disclosure of document D1

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/RU98/00353

and the normal knowledge of a person skilled in the art of signal detection systems.

1.2 The same considerations as made above in paragraph 1.1 in respect of claim 1 are also valid for **independent claim 6** since claim 6 includes the same feature combination as claim 1 in terms of a method claim.

Consequently, the subject-matter of claim 6 is neither new, Article 33(2) PCT, nor does it involve an inventive step, Article 33(3) PCT.

1.3 The same considerations as made in above paragraph 1.2 in respect of claim 6 are in essence also valid for **independent claim 11** since claim 11 is based on the same principle as claim 6.

The only additional feature of claim 11, i.e. the step of controlling a duration of said processing period on a basis of the currently computed confidence level value, is also disclosed in document **D1** (see in particular col. 3, lines 62-66; col. 21, lines 62-68).

Consequently, the subject-matter of claim 11 is neither new, Article 33(2) PCT, nor does it involve an inventive step, Article 33(3) PCT.

1.4 The same considerations as made above in paragraph 1.3 in respect of claim 11 are also valid for **independent claim 14** since claim 14 includes the same feature combination as claim 11 in terms of an apparatus claim.

Consequently, the subject-matter of claim 14 is neither new, Article 33(2) PCT, nor does it involve an inventive step, Article 33(3) PCT.

1.5 Document **D1** (see in particular col. 1, lines 6-9; col. 1, lines 49-53; col. 2, lines 29-39; col. 2, lines 61-65; col. 3, lines 9-11; col. 7, lines 22-25; col. 8, lines 31-47; col. 10, lines 9-15; col. 11, lines 8-10; col. 11, lines 50-68; col. 14, lines 40-43; col. 18, line 49 to col. 19, line 3; col. 21, lines 16-27) discloses, according to **all** the features of **claim 28**, a tone detection apparatus suitable for detecting call progress tones (see col. 1, lines 6-9), a call progress tone having a sequence of

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/RU98/00353

states (see col. 1, lines 49-53; col. 8, lines 31-33; col. 14, lines 40-43), said apparatus comprising an input for receiving an input signal potentially containing a call progress tone (see col. 1, lines 49-53), the signal being capable of being divided in a plurality of segments (see col. 2, lines 29-32), a spectral processing unit for processing said signal to generate a plurality of sets of data elements, the sets of data elements providing spectral information about respective segments of the input signal (see col. 2, lines 33-39; col. 8, lines 38-47), a logical processing unit coupled to said spectral processing unit for receiving and processing the sets of data elements, said logical processing unit being operative to compute over time successive classification elements for respective segments of the input signal, each of the successive classification elements indicating whether the properties of the signal during the time segment match the properties of a certain state of a certain call progress tone (see col. 3, lines 9-11; col. 7, lines 22-25; col. 11, lines 8-10; col. 11, lines 50-57; col. 18, line 49 to col. 19, line 3; col. 21, lines 16-27), said logical processing unit including an output for generating a result signal representative of the classification element computed by said logical processing unit (see col. 2, lines 61-65; col. 10, lines 9-15; col. 11, lines 58-68).

The subject-matter of claim 28 therefore is not new, Article 33(2) PCT.

It should furthermore be noted that even if novelty of claim 28 could be argued, based on minor differences between the features of said claim and those disclosed in document D1, the subject-matter of claim 28 would not involve an inventive step, Article 33(3) PCT, having regard to the disclosure of documents D1 and the normal knowledge of a person skilled in the art of signal detection systems.

1.6 The same considerations as made above in paragraph 1.5 in respect of claim 28 are also valid for **independent claim 31** since claim 31 includes the same feature combination as claim 28 in terms of a method claim.

Consequently, the subject-matter of claim 31 is neither new, Article 33(2) PCT, nor does it involve an inventive step, Article 33(3) PCT.

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/RU98/00353

1.7 Furthermore, dependent **claims 2 to 5, 7 to 10, 12, 13, 15, 16, 29, 30, 32 and 33** do not appear to contain any additional features which in combination with the features of any claim to which they refer, involve an inventive step for the reason that the subject-matter of said claims is either in principle directly derivable from the disclosure of document **D1** (for **claims 2 and 7**: see col. 3, lines 62-66; col. 21, lines 62-68; for **claims 4, 9, 13 and 16**: see col. 13, lines 48-51) or represents simple design details which are generally known to a person skilled in the field of signal detection systems.

Thus, dependent claims 2 to 5, 7 to 10, 12, 13, 15, 16, 29, 30, 32 and 33 do not meet the requirements of Article 33(3) PCT.

2. Claims 17 to 27:

2.1 The present invention as set out in claims 17 to 33 relates to a tone detection apparatus suitable for detection of call progress tones according to the features of **independent claim 17**, and to a corresponding method of performing tone detection suitable for the detection of call progress tones according to the features of **independent claim 22**.

2.2 Generally, tone detection apparatuses suitable for detection of call progress tones are well-known in the art. The document **D1** describes such a call progress tone detection apparatus, wherein a call progress tone is characterised by at least one frequency component and a timing behaviour defining a certain cadence. An input of said call progress tone detection apparatus receives an input signal potentially containing said call progress tone and divides said input signal in a plurality of consecutive sections. Said call progress tone detection apparatus comprises a spectral processing unit for processing said input signal to generate a plurality of sets of data elements. Moreover, said call progress tone detection apparatus comprises a cadence processing unit to compute over time successive confidence level values being indicative of a likelihood of existence of a certain cadence in the input signal. Furthermore, said cadence processing unit includes an output for generating a signal indicative of the confidence level value at the end of a processing period.

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/RU98/00353

2.3 A main **problem** related to the detection apparatuses described in D1 is that because of the fact that different types of signals are currently in use or will be introduced in the future and because of talk-off occurring when human speech, music, other sounds or noise are present, the detection of individual call progress tones solely by their cadence as described in D1 is not sufficiently reliable.

2.4 The present invention overcomes this problem by providing a tone detection apparatus suitable for detection of call progress tones according to the features of **independent claim 17**, and a corresponding method of performing tone detection suitable for the detection of call progress tones according to the features of **independent claim 22**.

According to the essential features of the invention, a frequency component processing unit is provided and coupled to said spectral processing unit for receiving sets of data elements and for processing the sets of data elements to output sets of classification data elements indicating whether a frequency component of a call progress tone exists in respective sections of the input signal. Further, the cadence processing unit is coupled to said frequency component processing unit for receiving and processing sets of classification data elements to compute over time said successive confidence level values for the input signal during a processing period encompassing the sections of the input signal that corresponds to the sets of classification data elements processed by the cadence processing unit.

2.5 The present invention provides the **advantages** of providing a more robust and more efficient call progress tone detection system that can be easily adapted to recognise current and future signalling conventions by detecting both the cadence and the frequency component of said call progress tone and by simply changing the necessary parameters of said classification data elements indicating whether a frequency component of a call progress tone exists.

2.6 The subject-matter of the present invention as claimed in respective independent claims 17 and 22 is neither disclosed in, nor rendered obvious by the remaining prior art documents cited in the International Search Report as said documents, which merely relate to a very general state of the art of detecting call tones, do not

describe the tone detection apparatus or method suitable for detection of call progress tones according to the particular feature combination of the present invention or part thereof as defined in respective independent claims 17 and 22.

- 2.7 The subject-matter of independent claims 1 and 22 therefore is considered to be new and to involve an inventive step, Article 33(2) and (3) PCT.
- 2.8 As claims 18 to 21 and 23 to 27 are dependent on respective claims 17 and 22, said claims 18 to 21 and 23 to 27 do also meet the requirements of Article 33(2) and (3) PCT.
- 2.9 The present invention as set out in claims 17 to 27 is susceptible of industrial application, Article 33(4) PCT.

B. Remarks made in respect of paragraph VII:

1. The independent claims should have been drafted in the proper two-part form recommended by Rule 6.3.(b),(i),(ii) PCT, having a preamble that correctly reflects the nearest prior art, being represented by the above noted document D1.
2. The claims do not include reference signs in parentheses where features shown in the drawings are referred to, Rule 6.2.(b) PCT.
3. In order to meet the requirements of Rule 5.1.(a),(ii) PCT, the relevant prior art, i.e. the document D1 noted above, should have been acknowledged by reference and briefly discussed in the introductory part of the description.
4. The opening part of the description should have been modified to bring it into agreement with any new independent claim, Rule 5.1.(a),(iii) PCT.
5. Following typing error are present in claims 2, 7, 18 and 23:
"... a defined in claim ..." should have been amended in "... as defined in claim ...".

6. The general "spirit" statement in the description at page 46, line 1, page 53, line 2 and page 58, line 24 is unclear, and when used to interpret the claims renders them also unclear, contrary to Article 6 PCT. The statement should therefore have been deleted.

C. Remarks made in respect of paragraph VIII:

1. The various definitions of the apparatus for performing cadence detection on a signal given in independent claims 1 and 16, and of corresponding method given in independent claims 6 and 11 are such that the claims as a whole are not concise, contrary to Article 6 PCT. Moreover, lack of clarity of the claims as a whole arises, since the plurality of independent claims makes it difficult, if not impossible, to determine the matter for which protection is sought, and places an undue burden on others seeking to establish the extent of the protection.

The same objection is also valid for the various definitions of the tone detection apparatus given in independent claims 17 and 28, and of corresponding method given in independent claims 22 and 31.

The claims should have been recast to include only the minimum necessary number of independent claims in any one category with dependent claims as appropriate, Rule 6.4 PCT.

In the present case it was considered appropriate to use only one independent claim relating to the apparatus for performing cadence detection on a signal, one independent claim relating to the corresponding method, one independent claim relating to the tone detection apparatus and one independent claim relating to the corresponding method, respectively.

3. The terms "substantially" or "certain" in **claims 1, 3 to 6, 8 to 11, 13, 14, 16, 17, 19 to 22, 24 to 26, 28, 29, 31 and 32** are unclear as it introduces inexactness into quantities or expressions and so leaves the reader in doubt as to the exact meaning of features qualified by such terms. Therefore, the term "substantially", should have been deleted and the term "certain" should have been amended in "predefined", Article 6 PCT.

PATENT COOPERATION TREATY

From the:
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

Fax No. 7501 787 2071

To:
KLIUKIN, Viacheslav, A.
Prechistensky Pereulok 14, build. 1
4 th Floor
Moscow 119034
FEDERATION DE RUSSIE

PCT

WRITTEN OPINION

(PCT Rule 66)

Date of mailing (day/month/year)	17.07.2000
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Applicant's or agent's file reference MO8881565WO	REPLY DUE	within 3 month(s) from the above date of mailing
International application No. PCT/RU98/00353	International filing date (day/month/year) 30/10/1998	Priority date (day/month/year) 30/10/1998
International Patent Classification (IPC) or both national classification and IPC H04M1/00		
Applicant NORTHERN TELECOM LIMITED et al.		

1. This written opinion is the first drawn up by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

- I Basis of the opinion
- II Priority
- III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV Lack of unity of invention
- V Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI Certain document cited
- VII Certain defects in the International application
- VIII Certain observations on the International application

3. The applicant is hereby invited to reply to this opinion.

When? See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).

How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

Also: For an additional opportunity to submit amendments, see Rule 66.4. For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 bis. For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the International preliminary examination report will be established on the basis of this opinion.

4. The final date by which the International preliminary examination report must be established according to Rule 69.2 is: 28/02/2001.

Name and mailing address of the International preliminary examining authority:

European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0 Tx: 523856 epmu d
Fax: +49 89 2399 - 4465

Authorized officer / Examiner

Banerjea, R

Formalities officer (incl. extension of time limits)
Finnie, A
Telephone No. +49 89 2399 8251



WRITTEN OPINION

International application No. PCT/RU98/00353

I. Basis of the opinion

1. This opinion has been drawn on the basis of (substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed".):

Description, pages:

1-58 as originally filed

Claims, No.:

1-33 as originally filed

Drawings, sheets:

1/15-15/15 as originally filed

2. The amendments have resulted in the cancellation of:

the description, pages:
 the claims, Nos.:
 the drawings, sheets:

3. This opinion has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims 1, 6, 11, 14
Inventive step (IS)	Claims 1-4, 6-9, 11-16
Industrial applicability (IA)	Claims

2. Citations and explanations

see separate sheet

WRITTEN OPINION

International application No. PCT/RU98/00353

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

**WRITTEN OPINION
SEPARATE SHEET**

International application No. PCT/RU98/00353

A. Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following document:

D1: US-A-5 023 906

1. Document D1 (see in particular col. 1, lines 49-53; col. 1, lines 65-68; col. 2, lines 27-39; col. 3, lines 9-11; col. 3, lines 62-66; col. 7, lines 19-25; col. 10, lines 9-15; col. 11, lines 8-10; col. 11, lines 50-68; col. 12, lines 18-20; col. 21, lines 62-68; Fig. 1) discloses, according to all the features of **claim 1**, an apparatus for performing cadence detection on a signal (see col. 1, lines 49-53), said apparatus comprising an input (see 15" in Fig. 1) for receiving an input signal potentially manifesting a certain cadence (see col. 7, lines 19-21), a signal processing functional block (see "10" in Fig. 1) coupled to said input for receiving the input signal, said signal processing functional block being operative to successively compute confidence level values over time during a processing period, a currently computed confidence level value being indicative of a likelihood of existence of a certain cadence in the input signal since a beginning of said processing period (see col. 1, lines 65-68; col. 2, lines 27-39; col. 3, lines 9-11; col. 7, lines 22-25; col. 11, lines 8-10; col. 11, lines 50-57), said processing period being characterised by a variable duration (see col. 3, lines 62-66; col. 21, lines 62-68), said signal processing functional block including an output for generating an output signal indicative of the confidence level value at the end of said processing period (see col. 2, lines 27-39; col. 10, lines 9-15; col. 11, lines 58-68; col. 12, lines 18-20).

The subject-matter of claim 1 therefore is not new, Article 33(2) PCT.

It should furthermore be noted that even if novelty of claim 1 could be argued, based on minor differences between the features of said claim and those disclosed in document D1, the subject-matter of claim 1 would not involve an

**WRITTEN OPINION
SEPARATE SHEET**

International application No. PCT/RU98/00353

inventive step, Article 33(3) PCT, having regard to the disclosure of document D1 and the normal knowledge of a person skilled in the art of signal detection systems.

2. The same considerations as made above in paragraph 1 in respect of claim 1 are also valid for **independent claim 6** since claim 6 includes the same feature combination as claim 1 in terms of a method claim.

Consequently, the subject-matter of claim 6 is neither new, Article 33(2) PCT, nor does it involve an inventive step, Article 33(3) PCT.

3. The same considerations as made in above paragraph 2 in respect of claim 6 are in essence also valid for **independent claim 11** since claim 11 is based on the same principle as claim 6.

The only additional feature of claim 11, i.e. the step of controlling a duration of said processing period on a basis of the currently computed confidence level value, is also disclosed in document D1 (see in particular col. 3, lines 62-66; col. 21, lines 62-68).

Consequently, the subject-matter of claim 11 is neither new, Article 33(2) PCT, nor does it involve an inventive step, Article 33(3) PCT.

4. The same considerations as made above in paragraph 3 in respect of claim 11 are also valid for **independent claim 14** since claim 14 includes the same feature combination as claim 11 in terms of an apparatus claim.

Consequently, the subject-matter of claim 14 is neither new, Article 33(2) PCT, nor does it involve an inventive step, Article 33(3) PCT.

5. Furthermore, dependent claims 2 to 4, 7 to 9, 12, 13, 15 and 16 do not appear to contain any additional features which in combination with the features of any claim to which they refer, involve an inventive step for the reason that the subject-matter of said claims is either in principle directly derivable from the disclosure of

**WRITTEN OPINION
SEPARATE SHEET**

International application No. PCT/RU98/00353

document D1 (for **claims 2 and 7**: see col. 3, lines 62-66; col. 21, lines 62-68; for **claims 4, 9, 13 and 16**: see col. 13, lines 48-51) or represents simple design details which are generally known to a person skilled in the field of signal detection systems.

Thus, dependent claims 2 to 4, 7 to 9, 12, 13, 15 and 16 do not meet the requirements of Article 33(3) PCT.

B. Re Item VII**Certain defects in the international application**

1. The independent claims should be drafted in the proper two-part form recommended by Rule 6.3.(b),(i),(ii) PCT, having a preamble that correctly reflects the nearest prior art, being represented by the above noted document D1.
2. All the claims should include reference signs in parentheses where features shown in the drawings are referred to, Rule 6.2.(b) PCT.
3. In order to meet the requirements of Rule 5.1.(a),(ii) PCT, the relevant prior art, i.e. the document D1 noted above, should be acknowledged by reference and briefly discussed in the introductory part of the description.
4. The opening part of the description should be modified to bring it into agreement with any new independent claim, Rule 5.1.(a),(iii) PCT.
5. Following typing error are present in claims 2, 7, 18 and 23:
"... a defined in claim ..." should be amended in "... as defined in claim ...".
6. The general "spirit" statement in the description at page 46, line 1, page 53, line 2 and page 58, line 24 is unclear, and when used to interpret the claims renders them also unclear, contrary to Article 6 PCT. The statement should therefore be deleted.

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International application No. PCT/RU98/00353

7. The attention of the applicant is drawn to the fact that the application may not be amended in such a way that it contains subject-matter which extends beyond the content of the application as originally filed, Article 34(2)(b) PCT.
8. In order to facilitate the examination of the conformity of the amended application with the requirements of Article 34(2)(b) PCT, the applicant is requested to clearly identify the amendments carried out, no matter whether they concern amendments by addition, replacement or deletion, and to indicate the passages of the application as filed on which these amendments are based, Rule 66.8(a) PCT.
9. Amendments should be filed by way of replacement pages in the manner stipulated by Rule 66.8(a) PCT. In particular, fair copies of the amendments should be filed preferably in triplicate. Moreover, the applicant's attention is drawn to the fact that, as a consequence of Rule 66.8(a) PCT the examiner is not permitted to carry out any amendments under the PCT procedure, however minor these may be.

C. Re Item VIII**Certain observations on the international application**

1. The various definitions of the apparatus for performing cadence detection on a signal given in independent **claims 1 and 16**, and of corresponding method given in independent **claims 6 and 11** are such that the claims as a whole are not concise, contrary to Article 6 PCT. Moreover, lack of clarity of the claims as a whole arises, since the plurality of independent claims makes it difficult, if not impossible, to determine the matter for which protection is sought, and places an undue burden on others seeking to establish the extent of the protection.

The same objection is also valid for the various definitions of the tone detection apparatus given in independent **claims 17 and 28**, and of corresponding method given in independent **claims 22 and 31**.

WRITTEN OPINION
SEPARATE SHEET

International application No. PCT/RU98/00353

The claims should be recast to include only the minimum necessary number of independent claims in any one category with dependent claims as appropriate, Rule 6.4 PCT.

In the present case it is considered appropriate to use only one independent claim relating to the apparatus for performing cadence detection on a signal, one independent claim relating to the corresponding method, one independent claim relating to the tone detection apparatus and one independent claim relating to the corresponding method, respectively.

It should be noted that any independent claim should meet the requirement following from Article 6 PCT taken in combination with Rule 6.3 PCT that any independent claim must contain all the technical features essential to the invention.

2. It is clear from the present description on page 8, lines 10-32; page 47, lines 31-34 that the features describing that:

... the signal processing functional block is operative to terminate said processing period, when the currently computed confidence level value and an amount of time remaining in the processing period before reaching said value indicate, that a cadence is unlikely to be detected before reaching said value ...

are essential technical features of the present invention.

Since **claim 1** does not contain these features it does not meet the requirement following from Article 6 PCT taken in combination with Rule 6.3(a) PCT that any independent claim must contain all the technical features essential to the invention.

This deficiency could be overcome by adding the features of **claim 5** to those of present claim 1.

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International application No. PCT/RU98/00353

The same objection also applies to independent **claims 6, 11, 14, 17, 22, 28 and 31.**

3. The terms "substantially" or "certain" in **claims 1, 3 to 6, 8 to 11, 13, 14, 16, 17, 19 to 22, 24 to 26, 28, 29, 31 and 32** are unclear as it introduces inexactness into quantities or expressions and so leaves the reader in doubt as to the exact meaning of features qualified by such terms. Therefore, the term "substantially", should be deleted and the term "certain" should be amended in "predefined", Article 6 PCT.

PATENT COOPERATION TREATY

From the:
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

KLIUKIN, Viacheslav, A.
Prechistensky Pereulok 14, build. 1
4 th Floor
Moscow 119034
FEDERATION DE RUSSIE

PCT

WRITTEN OPINION

(PCT Rule 66)

Date of mailing
(day/month/year) 22.12.2000

Applicant's or agent's file reference MO8881565WO	REPLY DUE	within 1 month(s) from the above date of mailing
International application No. PCT/RU98/00353	International filing date (day/month/year) 30/10/1998	Priority date (day/month/year) 30/10/1998
International Patent Classification (IPC) or both national classification and IPC H04M1/00		
Applicant NORTHERN TELECOM LIMITED et al.		

1. This written opinion is the **second** drawn up by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

- I Basis of the opinion
- II Priority
- III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV Lack of unity of invention
- V Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI Certain document cited
- VII Certain defects in the international application
- VIII Certain observations on the international application

3. The applicant is hereby **invited to reply** to this opinion.

When? See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).

How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

Also: For an additional opportunity to submit amendments, see Rule 66.4. For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 bis. For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 28/02/2001.

Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer / Examiner Banerjea, R Formalities officer (incl. extension of time limits) Le Nadan, M Telephone No. +49 89 2399 2350
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WRITTEN OPINION

International application No. PCT/RU98/00353

I. Basis of the opinion

1. This opinion has been drawn on the basis of (substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed");

Description, pages:

1-58 as originally filed

Claims, No.:

1-33 as originally filed

Drawings, sheets:

1/15-15/15 as originally filed

2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- the language of publication of the international application (under Rule 48.3(b)).
- the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- contained in the international application in written form.
- filed together with the international application in computer readable form.
- furnished subsequently to this Authority in written form.
- furnished subsequently to this Authority in computer readable form.
- The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- the description, pages:
- the claims, Nos.:

the drawings, sheets:

5. This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):
(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:
see separate sheet

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims 1, 6, 11, 14, 28, 31
Inventive step (IS)	Claims 2-4, 7-9, 12, 13, 15, 16, 29, 30, 32, 33
Industrial applicability (IA)	Claims

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

A. Re Item I

Basis of the opinion, additional observations

Reference is made to the following document:

D1: US-A-5 023 906

Having reconsidered the subject-matter of the present set of claims 1 to 33 in the light of the prior art document D1 cited in the International Search Report, further objections are raised, which have not been addressed in the first Written Opinion dated 17.07.2000. Accordingly, present Written Opinion covers both objections, i.e. the objections already made in the first Written Opinion and the new further objections (see in particular below Item V, paragraphs 5 to 7).

B. Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Document **D1** (see in particular col. 1, lines 49-53; col. 1, lines 65-68; col. 2, lines 27-39; col. 3, lines 9-11; col. 3, lines 62-66; col. 7, lines 19-25; col. 10, lines 9-15; col. 11, lines 8-10; col. 11, lines 50-68; col. 12, lines 18-20; col. 21, lines 62-68; Fig. 1) discloses, according to all the features of **claim 1**, an apparatus for performing cadence detection on a signal (see col. 1, lines 49-53), said apparatus comprising an input (see "15" in Fig. 1) for receiving an input signal potentially manifesting a certain cadence (see col. 7, lines 19-21), a signal processing functional block (see "10" in Fig. 1) coupled to said input for receiving the input signal, said signal processing functional block being operative to successively compute confidence level values over time during a processing period, a currently computed confidence level value being indicative of a likelihood of existence of a certain cadence in the input signal since a beginning of said processing period (see col. 1, lines 65-68; col. 2, lines 27-39; col. 3, lines 9-11; col. 7, lines 22-25; col. 11, lines 8-10; col. 11, lines 50-57), said processing period being characterised by a variable duration (see col. 3, lines 62-66; col. 21, lines 62-68),

said signal processing functional block including an output for generating an output signal indicative of the confidence level value at the end of said processing period (see col. 2, lines 27-39; col. 10, lines 9-15; col. 11, lines 58-68; col. 12, lines 18-20).

The subject-matter of claim 1 therefore is not new, Article 33(2) PCT.

It should furthermore be noted that even if novelty of claim 1 could be argued, based on minor differences between the features of said claim and those disclosed in document D1, the subject-matter of claim 1 would not involve an inventive step, Article 33(3) PCT, having regard to the disclosure of document D1 and the normal knowledge of a person skilled in the art of signal detection systems.

2. The same considerations as made above in paragraph 1 in respect of claim 1 are also valid for **independent claim 6** since claim 6 includes the same feature combination as claim 1 in terms of a method claim.

Consequently, the subject-matter of claim 6 is neither new, Article 33(2) PCT, nor does it involve an inventive step, Article 33(3) PCT.

3. The same considerations as made in above paragraph 2 in respect of claim 6 are in essence also valid for **independent claim 11** since claim 11 is based on the same principle as claim 6.

The only additional feature of claim 11, i.e. the step of controlling a duration of said processing period on a basis of the currently computed confidence level value, is also disclosed in document D1 (see in particular col. 3, lines 62-66; col. 21, lines 62-68).

Consequently, the subject-matter of claim 11 is neither new, Article 33(2) PCT, nor does it involve an inventive step, Article 33(3) PCT.

4. The same considerations as made above in paragraph 3 in respect of claim 11 are also valid for **independent claim 14** since claim 14 includes the same feature combination as claim 11 in terms of an apparatus claim.

Consequently, the subject-matter of claim 14 is neither new, Article 33(2) PCT, nor does it involve an inventive step, Article 33(3) PCT.

5. Document **D1** (see in particular col. 1, lines 6-9; col. 1, lines 49-53; col. 2, lines 29-39; col. 2, lines 61-65; col. 3, lines 9-11; col. 7, lines 22-25; col. 8, lines 31-47; col. 10, lines 9-15; col. 11, lines 8-10; col. 11, lines 50-68; col. 14, lines 40-43; col. 18, line 49 to col. 19, line 3; col. 21, lines 16-27) discloses, according to all the features of **claim 28**, a tone detection apparatus suitable for detecting call progress tones (see col. 1, lines 6-9), a call progress tone having a sequence of states (see col. 1, lines 49-53; col. 8, lines 31-33; col. 14, lines 40-43), said apparatus comprising an input for receiving an input signal potentially containing a call progress tone (see col. 1, lines 49-53), the signal being capable of being divided in a plurality of segments (see col. 2, lines 29-32), a spectral processing unit for processing said signal to generate a plurality of sets of data elements, the sets of data elements providing spectral information about respective segments of the input signal (see col. 2, lines 33-39; col. 8, lines 38-47), a logical processing unit coupled to said spectral processing unit for receiving and processing the sets of data elements, said logical processing unit being operative to compute over time successive classification elements for respective segments of the input signal, each of the successive classification elements indicating whether the properties of the signal during the time segment match the properties of a certain state of a certain call progress tone (see col. 3, lines 9-11; col. 7, lines 22-25; col. 11, lines 8-10; col. 11, lines 50-57; col. 18, line 49 to col. 19, line 3; col. 21, lines 16-27), said logical processing unit including an output for generating a result signal representative of the classification element computed by said logical processing unit (see col. 2, lines 61-65; col. 10, lines 9-15; col. 11, lines 58-68).

The subject-matter of claim 28 therefore is not new, Article 33(2) PCT.

It should furthermore be noted that even if novelty of claim 28 could be argued, based on minor differences between the features of said claim and those disclosed in document D1, the subject-matter of claim 28 would not involve an inventive step, Article 33(3) PCT, having regard to the disclosure of documents D1 and the normal knowledge of a person skilled in the art of signal detection systems.

6. The same considerations as made above in paragraph 5 in respect of claim 28 are also valid for **independent claim 31** since claim 31 includes the same feature combination as claim 28 in terms of a method claim.

Consequently, the subject-matter of claim 31 is neither new, Article 33(2) PCT, nor does it involve an inventive step, Article 33(3) PCT.

7. Furthermore, dependent **claims 2 to 4, 7 to 9, 12, 13, 15, 16, 29, 30, 32 and 33** do not appear to contain any additional features which in combination with the features of any claim to which they refer, involve an inventive step for the reason that the subject-matter of said claims is either in principle directly derivable from the disclosure of document D1 (for **claims 2 and 7**: see col. 3, lines 62-66; col. 21, lines 62-68; for **claims 4, 9, 13 and 16**: see col. 13, lines 48-51) or represents simple design details which are generally known to a person skilled in the field of signal detection systems.

Thus, dependent claims 2 to 4, 7 to 9, 12, 13, 15, 16, 29, 30, 32 and 33 do not meet the requirements of Article 33(3) PCT.

C. Re Item VII

Certain defects in the international application

1. The independent claims should be drafted in the proper two-part form recommended by Rule 6.3.(b),(i),(ii) PCT, having a preamble that correctly reflects the nearest prior art, being represented by the above noted document D1.

2. All the claims should include reference signs in parentheses where features shown in the drawings are referred to, Rule 6.2.(b) PCT.
3. In order to meet the requirements of Rule 5.1.(a),(ii) PCT, the relevant prior art, i.e. the document D1 noted above, should be acknowledged by reference and briefly discussed in the introductory part of the description.
4. The opening part of the description should be modified to bring it into agreement with any new independent claim, Rule 5.1.(a),(iii) PCT.
5. Following typing error are present in claims 2, 7, 18 and 23:
"... a defined in claim ..." should be amended in "... as defined in claim ...".
6. The general "spirit" statement in the description at page 46, line 1, page 53, line 2 and page 58, line 24 is unclear, and when used to interpret the claims renders them also unclear, contrary to Article 6 PCT. The statement should therefore be deleted.
7. The attention of the applicant is drawn to the fact that the application may not be amended in such a way that it contains subject-matter which extends beyond the content of the application as originally filed, Article 34(2)(b) PCT.
8. In order to facilitate the examination of the conformity of the amended application with the requirements of Article 34(2)(b) PCT, the applicant is requested to clearly identify the amendments carried out, no matter whether they concern amendments by addition, replacement or deletion, and to indicate the passages of the application as filed on which these amendments are based, Rule 66.8(a) PCT.
9. Amendments should be filed by way of replacement pages in the manner stipulated by Rule 66.8(a) PCT. In particular, fair copies of the amendments should be filed preferably in triplicate. Moreover, the applicant's attention is drawn to the fact that, as a consequence of Rule 66.8(a) PCT the examiner is not permitted to carry out any amendments under the PCT procedure, however minor these may be.

D. Re Item VIII

Certain observations on the international application

1. The various definitions of the apparatus for performing cadence detection on a signal given in independent **claims 1 and 16**, and of corresponding method given in independent **claims 6 and 11** are such that the claims as a whole are not concise, contrary to Article 6 PCT. Moreover, lack of clarity of the claims as a whole arises, since the plurality of independent claims makes it difficult, if not impossible, to determine the matter for which protection is sought, and places an undue burden on others seeking to establish the extent of the protection.

The same objection is also valid for the various definitions of the tone detection apparatus given in independent **claims 17 and 28**, and of corresponding method given in independent **claims 22 and 31**.

The claims should be recast to include only the minimum necessary number of independent claims in any one category with dependent claims as appropriate, Rule 6.4 PCT.

In the present case it is considered appropriate to use only one independent claim relating to the apparatus for performing cadence detection on a signal, one independent claim relating to the corresponding method, one independent claim relating to the tone detection apparatus and one independent claim relating to the corresponding method, respectively.

It should be noted that any independent claim should meet the requirement following from Article 6 PCT taken in combination with Rule 6.3 PCT that any independent claim must contain all the technical features essential to the invention.

2. The terms "substantially" or "certain" in **claims 1, 3 to 6, 8 to 11, 13, 14, 16, 17, 19 to 22, 24 to 26, 28, 29, 31 and 32** are unclear as it introduces inexactness into quantities or expressions and so leaves the reader in doubt as to the exact meaning of features qualified by such terms. Therefore, the term "substantially", should be deleted and the term "certain" should be amended in "predefined", Article 6 PCT.

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL SEARCH REPORT
OR THE DECLARATION

(PCT Rule 44.1)

To: KLIUKIN, Viacheslav, A. B. Palashevsky Pereulok 3 Suite 2 Moscow 103104 RUSSIAN FEDERATION		Date of mailing (day/month/year) 28/07/1999
Applicant's or agent's file reference		FOR FURTHER ACTION See paragraphs 1 and 4 below
International application No. PCT/RU 98/00353		International filing date (day/month/year) 30/10/1998
Applicant NORTHERN TELECOM LIMITED et al.		

1. The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:

The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. With regard to the protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after 18 months from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90bis.1 and 90bis.3, respectively, before the completion of the technical preparations for international publication.

Within 19 months from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within 20 months from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority  European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Grace Casuga
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These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When? Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How? Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

- (i) the claim is unchanged;
- (ii) the claim is cancelled;
- (iii) the claim is new;
- (iv) the claim replaces one or more claims as filed;
- (v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."
2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."
3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."
4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international application is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No.	International filing date (day/month/year)	(Earliest) Priority Date (day/month/year)
PCT/RU 98/ 00353	30/10/1998	
Applicant		
NORTHERN TELECOM LIMITED et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

contained in the international application in written form.

filed together with the international application in computer readable form.

furnished subsequently to this Authority in written form.

furnished subsequently to this Authority in computer readable form.

the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. **Certain claims were found unsearchable** (See Box I).

3. **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

the text is approved as submitted by the applicant.

the text has been established by this Authority to read as follows:

METHOD AND APPARATUS FOR DETECTING SIGNALLING TONES

5. With regard to the **abstract**,

the text is approved as submitted by the applicant.

the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

as suggested by the applicant.

because the applicant failed to suggest a figure.

because this figure better characterizes the invention.

3

None of the figures.

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04M1/00

H01Q1/457

H04Q1/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04M H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 550 144 A (AMERICAN TELEPHONE & TELEGRAPH) 7 July 1993 (1993-07-07) page 3, line 3 - line 13 page 5, line 15 - line 17 page 8, line 51 - page 9, line 14 page 12, line 50 page 13, line 32 page 15, line 3 page 15, line 48 ---	1-33
A	US 5 023 906 A (NOVAS ROBERT G) 11 June 1991 (1991-06-11) column 2, line 27 - column 3, line 11 column 8, line 38 - line 40 column 10, line 19 - line 27 ---	1-33
	-/-	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents :

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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search

20 July 1999

Date of mailing of the international search report

28/07/1999

Name and mailing address of the ISA

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Authorized officer

Schweitz, M

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 321 745 A (DRORY EATAMAR ET AL) 14 June 1994 (1994-06-14) column 1, line 35 - line 49 column 7, line 39 - line 55 column 12, line 60 - column 13, line 16 ----	1-33
A	US 5 477 465 A (ZHENG BAOHUA) 19 December 1995 (1995-12-19) column 4, line 1 - line 8 -----	1-33

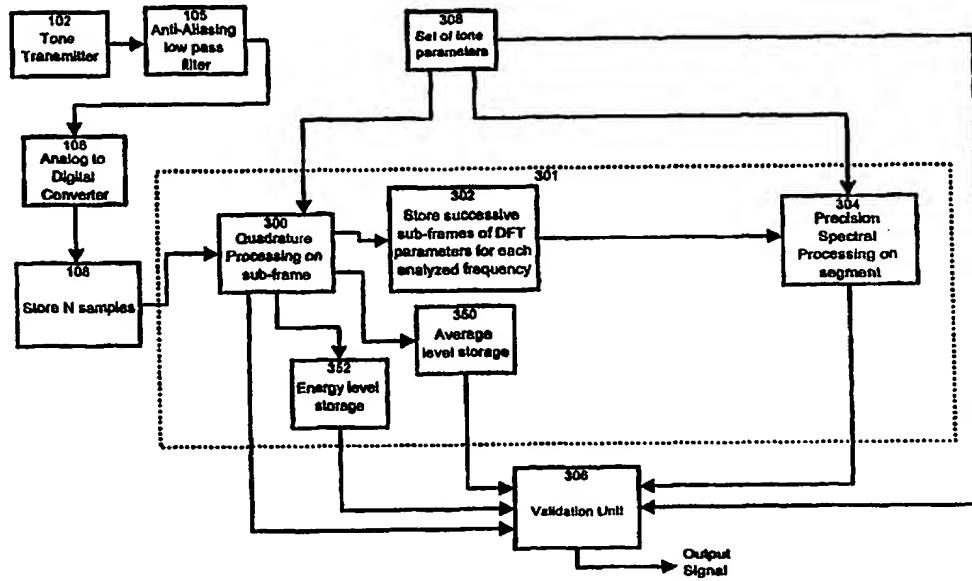
Patent document cited in search report		Publication date		Patent family member(s)		Publication date
EP 0550144	A	07-07-1993		US 5442696 A AU 643632 B AU 3006192 A CA 2081535 A,C JP 6086338 A		15-08-1995 18-11-1993 08-07-1993 01-07-1993 25-03-1994
US 5023906	A	11-06-1991		US 5521967 A US 5325425 A		28-05-1996 28-06-1994
US 5321745	A	14-06-1994		US 5319703 A CA 2096188 A DE 69317015 D DE 69317015 T EP 0575725 A JP 6153244 A AT 127303 T DE 69300413 D DE 69300413 T EP 0573760 A		07-06-1994 27-11-1993 26-03-1998 10-06-1998 29-12-1993 31-05-1994 15-09-1995 05-10-1995 01-02-1996 15-12-1993
US 5477465	A	19-12-1995		NONE		



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : H04M 1/00, H04Q 1/457, 1/46		A1	(11) International Publication Number: WO 00/30325
			(43) International Publication Date: 25 May 2000 (25.05.00)
<p>(21) International Application Number: PCT/RU98/00353</p> <p>(22) International Filing Date: 30 October 1998 (30.10.98)</p> <p>(71) Applicant (for all designated States except US): NORTHERN TELECOM LIMITED [CA/CA]; Station A, P.O. Box 6123, Montreal, Quebec H3C 3J5 (CA).</p> <p>(72) Inventors; and</p> <p>(75) Inventors/Applicants (for US only): LEONG, Michael [CA/CA]; 2266 Saint-Jacques West, Montreal, Quebec H3J 2M7 (CA). ZAKHAROV, Yuri [RU/RU]; pr. Mira, 146-27, Moscow, 129366 (RU).</p> <p>(74) Agent: KLJUKIN, Vyacheslav Alexandrovich; B.Palashevsky Pereulok, 3, Moscow, 103104 (RU).</p>		<p>(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p>Published <i>With international search report.</i></p>	

(54) Title: METHOD AND APPARATUS FOR DETECTING SIGNALLING TONES



(57) Abstract

A general purpose network tone detection method and apparatus that allows the precise and accurate recognition of North American tones (MF, DTMF (Dual-Tone Multifrequency) and CPT (Call Progress Tones)) and international MF-R2 tones as well as taking into consideration other common tones such as Calling Card Service Prompt and Recall Dial. Through the use of the Discrete Fourier Transform (DFT) on small time windows and by providing phase continuity between these windows, the results of the successive DFTs may be combined and processed by a second DFT computation. This second DFT allows higher frequency resolution without requiring the re-computation of the DFT from the time samples.

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Title: METHOD AND APPARATUS FOR DETECTING SIGNALLING TONES

Field of the invention

5 This invention relates to a method and an apparatus for detecting and discriminating between various types of electronic signals. More specifically it relates to telephone call processing and is particularly applicable to audible tones such as call progress tones (CPT) specifically in the area of telephone
10 networks.

Background of the Invention

Telephone service providers increasingly supply a wide variety of options and features to subscribers, such as call waiting, 15 three-way calling and credit card calling among many others. All these services are implemented to provide customers with conveniences and facilities that were unavailable a few years back.

In order to achieve communication between various units of a telephone network and with users and hence provide these services, 20 telephone systems require various types of control signals. These signals include tones which are used to convey information to the system from the user or, alternatively, to inform the user of the current status of a telephone transaction. Tones may also be used to communicate between switches and other parts of the telephone
25 network itself.

The correct detection of a tone is crucial to the functioning of the telephone network since the latter relies on them for operations such as dialling, billing and coin identification. Users 30 also rely on these tones for information such as busy, dialling and dial tone. As a concrete example, automatic redial when faced with a billing signal and recognition of an incoming fax would not be possible without accurate tone recognition.

Four categories of signalling are commonly used each with its own specifications and purposes. They are multi-frequency (MF) tones, dual-tone multi-frequency tones (DTMF), international MF-R2 tones and call progress tones (CPT). There are other signalling sequences that are not mentioned here since their purposes are similar in nature to the four signalling conventions mentioned above. Of particular interest here are call progress tones (CPT). Two separate devices are involved in the tone communication process: the transmitter, which creates and propagates the tones, and the receiver, which receives and decodes them.

Detection of tones is a problem that has been addressed in the past. For example Bennett et al., U.S. Patent 5,311,589 assigned 15 to AT&T Bell Laboratories, describes a method to process DTMF and CPT tone using the Goertzel algorithm and a logical processing stage. The contents of this document are hereby incorporated by reference.

20 The correct detection of a tone by the receiver implies that the signal originating from a transmitter station is accurately decoded by the receiver as being the transmitted tone. Correct detection by the receiver of a digit encoded using any signalling methods also requires both a valid combination of frequencies and 25 the correct timing element. A valid combination of frequencies implies that the receiver is able to discern that there is only the specified frequencies present and that these frequencies are located at or at least within reasonable distance of the nominal values. Furthermore the receiver is also able to verify within 30 reasonable accuracy that the amplitude, twist and other characteristics of the tone conforms to certain pre-determined values. The receiver should also be able to obtain within reasonable accuracy the duration of tone in order to determine if it is valid when compared to pre-determined duration requirements 35 such as inter-tone gaps, cadence and other temporal specifications.

Tone receiver systems have been developed in many parts of the world and, although it is difficult to describe a standard tone receiver architecture, some characteristics are shared between many of them. Figure 1 illustrates a typical tone receiver system as present in the prior art. A typical tone communication system of the type depicted in Figure 1 generally comprises a device such as a transmitter 102 which encodes and transmits tones serially in a communication channel. The transmitter 102 could be a simple touch-tone telephone or be included as part of a telephone switch. 10 A combination of the tones transmitted constitutes a tone pattern which typically has frequencies in the voice range (~ 180 - 3600 Hz). Hence, in a telephone network, the communication channel is the voice channel. At the other end of the channel a receiver 100 is connected. The receiver 100 monitors the communication channel, 15 detects and decodes the signal and, in turn, transmits the decoded information to another device such as a controller 116.

A typical prior art receiver 100 can be separated into five functional blocks namely an anti-aliasing low-pass filter 105, an 20 analog to digital (A/D) converter 106, a storage buffer unit 108, a spectral processor 110 and a validation unit 112. Although a few receivers still use the analog signal directly, the trend is clearly towards digitisation because it can be processed by a digital computer and be implemented on an easily programmable DSP 25 chip. In certain circumstances, the incoming signal may be digital.

In these cases the A/D converter 106 would not be required. Typically, the incoming signal is digitally sampled by an analog to digital (A/D) 106 converter and assembled into frames in a storage buffer unit 108. These frames are then analysed at 30 predetermined frequencies in order to obtain the frequency characteristics of the signal during that frame. Generally, the analysis is performed in two separate units 110 112.

The spectral processor 110 analyses the spectral 35 characteristics of the samples received from the storage buffer unit 108 to obtain frequency and amplitude information for each

frame. This analysis is similar for all types of signals differing perhaps by the frequencies analysed. Furthermore, this operation requires large computational power and limits the system in its processing capability. Traditionally, the spectral properties of 5 tones have been detected by means of a bank of bandpass filters, one for each possible frequency in the tone. This is shown in figure 2 for the detection of a Multi-Frequency (MF) tone. The filters 200 202 204 206 208 210 may be digital or analog, and are used to estimate the energies of narrow bands of the spectrum in 10 order to obtain a frequency representation of the signal. The bands are centred at the frequencies of interest and their width is chosen to reflect the frequency tolerance of the receiver of each analysed frequency. In the case of MF signalling, a tone is registered as present if and only if there is sufficient energy in 15 two spectral bands. This can be verified by means of devices comprising an energy computation and a pre-determined amplitude threshold 212 214 216 218 220 222. Another technique that can also be commonly used to analyse the spectral characteristics of the signals involves the computation of the Discrete Fourier Transform 20 (DFT). Typically the DFTs are computed only at the frequencies of interest and result in an estimation of energy in the frequency domain. This method is described in detail in "Discrete-Time Processing of Speech Signals" by Deller, Proakis and Hansen, Macmillan Publishing Company New York 1993 whose contents are 25 hereby incorporated by reference. Energy estimates obtained at this stage are propagated to the validation unit 112.

The validation unit 112 determines, based on the information obtained from the previous stage, if a valid tone has been detected 30 by evaluating the temporal and logical characteristics of the signal. Using the computed amplitude of each frequency, a candidate tone is determined for each frame and is often compared to previous frames for continuity. For instance, in the case of MF signalling, two and only two frequencies must be above the 35 energy threshold. In any other circumstance either the signal should be ignored or an error should be reported. The temporal

characteristic involves comparing the duration and cadence of the tone with respect to some reference template. In the case of MF and DTMF signals this temporal analysis is limited to short time duration signals typically in the range of 10ms to 40ms. For example, in the case of a DTMF digit with a frame length is 10ms, three consecutive frames are compared in order to conform to established standards and obtain 30ms duration for the tone. In the case of a CPT tone, a larger number of frames may be required to verify if the pattern of the given tone matches a predefined pattern with the same frequencies. A detailed description of logical processing can be found in Bennett et al., U.S. Patent 5,311,589 assigned to AT&T Bell Laboratories for both CPT and DTMF tones. Once either a valid tone or no tone has been detected, the result is sent to another device such as a controller 116 that uses the decoded information. The type of computation performed in the logical processing block is generally not computationally intensive and varies a lot between different signalling protocols.

Tone receivers of the type described above have been used in the past in tone detection and recognition systems. Such systems are often integrated into telephone networks where the different modules of the communication channels are able to communicate by sending and receiving various tones. Of particular interest here are call progress tones (CPT) which are commonly used to provide call progress information to users and other components of the system. Call progress tones generally comprise a frequency component and a timing component, the latter herein referred to as the cadence. The table below shows the frequency components of frequently used CPT tones.

30

f1/f2 Hz	0	440	480	620
350		Dial Tone/ Stutter Dial Tone		
440	Call Waiting/		Ringing	

f1/f2 Hz	0	440	480	620
	Variations			
480				Busy/ Reorder

As shown in the above table, the "Call Waiting" tone is composed of a single frequency at 440Hz and the busy tone is composed of two frequencies namely one at 480Hz and one at 620Hz.

5

The table below illustrates the frequency and timing behaviours of common CPT tones. Note that Dial, Ring, Busy and Reorder are dual-tones (i.e. 2 frequencies) while the SIT is a concatenation of three mono-tones (i.e. 1 frequency).

10

Tone Type	Freq. Components (Hz)	Timing Information
Dial	350.0 + 440.0	Steady
Ring	440.0 + 480.0	Cadence of 2.0s ON, 4.0s OFF
Busy	480.0 + 620.0	Cadence of 0.5s ON, 0.5s OFF
Reorder	480.0 + 620.0	Cadence of 0.25s ON, 0.25s OFF
Fax Calling (CNG)	1100 Hz	Cadence of 0.5s ON, 3.0sec OFF, 0.5s ON, 3.0sec OFF
SIT	913.8, 1370.6, 1776.7	274ms, 274ms, 380ms

The difficulty concerning the detection of tones is two-fold. The first problem lies in the fact that many different types of signals are currently in use or will be introduced in the future. A main deficiency of the current systems is their lack of flexibility and the difficulty of reprogramming the Discrete Fourier Transform (DFT) in order to adapt to new tones such as Special Information tones (SIT), fax calling tones (CNG), recall

· dialling tones amongst many others. This difficulty implies considerable efforts in the redesign of new systems to accommodate these new tones and hence considerable costs.

5 Another problem lies in the difficulty in providing precise control of the time duration of a signal that is caused by the long frames required to have a high frequency resolution. In order to have a high frequency resolution in DFT computations and hence be able to distinguish smaller and smaller portions of the frequency 10 spectrum, a long time interval or window is required. By doing so, the time resolution and hence the capacity of distinguishing between short time intervals is decreased. This is known as the frequency/time resolution trade-off.

15 Another difficulty resides in providing precise control over the frequency spectrum. About a nominal candidate frequency F_0 , which is one of the frequencies of a given tone, a small error margin is accepted to take channel distortions and other physical effects into account. The old band-pass filter technique does not 20 allow precise control of the frequency tolerance bands unless the filter order is very elevated which in turn is costly. As a result, the false classification of a detected tone may occur or alternatively, speech signals may be mistaken for an audible tone. Another problem in the telephone network is that several types of 25 devices interact using CPT tones. Some CPT tones are generated by recent equipment and are likely to conform to precise tolerance requirements. Other CPT tones may be generated by older equipment and may have different tolerance requirements. Additionally, CPT tones generated by older equipment may not conform to tolerances · 30 at all since the number of previously used tones was low and they were essentially used for human detection. CPT tones have traditionally been used to convey to the user information regarding the telephone connection. In some applications, it may be preferable to detect CPT tones with very precise tolerance since 35 the error of a false detection may be severe. In other applications, it may be preferable to relax the tolerance.

Commonly, in order to provide flexibility in the frequency tolerance, two separate filters or two different DFT computations are performed in order to apply different tolerances at the same frequency. These DFT computations are generally performed directly on the source samples using different window sizes. The use of two separate filters generally results in high computational costs as well as high hardware costs.

Another deficiency of the current system particularly relevant for CPT tone detection is the cadence validation. For CPT tone detection, the time pattern component, herein referred to as the cadence component, must be validated in addition to the frequency component. A specific example will better illustrate this problem.

The fax calling tone (CNG) is characterised by the following cadence {0.5 sec. ON; 3.0 sec. OFF; 0.5 sec. ON}. In order to detect this tone the CPT tone detector is configured to validate the sequence of three events pulse-silence-pulse. For the case that the observation begins at the start of the silence interval, the time to detect the full pattern is 3.0sec + 0.5 sec + 3.0sec + 0.5 sec = 7.0sec. Hence, a 7.0 second time interval is needed to provide sufficient time to see both ON pulses. This time interval is herein referred to as the observation window. This time delay contributes to the system's holding time and may be aggravating to a human waiting for the system to respond. A common solution to this problem is to specify a shortened version of the cadence pattern. For example the single 0.5 sec ON with an observation window of 3.5 sec. However, this method may lead to erroneous detection. Another alternative would be to specify a longer pattern such as 0.5 sec. ON and 3.0 sec OFF with a observation window of 6.5 sec. However the improvement over the full 7.0 seconds is only marginal.

The other problems of detecting tones arise from the nature of the telephone network itself. In the normal course of tone detection it may occur that a speech utterance is mistaken for a

tone, that a tone is not detected or that a given tone is mistaken for another. Although dual frequencies in MF, DTMF and CPT were chosen to be non-harmonically related and hence have little resemblance to the harmonic characteristic of the human voice, 5 these tones have frequencies located in the same band as speech (~ 180-3600 Hz). Human speech as well, has many fundamental and harmonic frequencies located in that band which causes a situation called "talk-off". Talk-off occurs when human speech, music or other sounds are mistaken for a tone in a telephone network 10 context. This problem is compounded by noise on the lines since noise may occur in all frequency bands. Another problem that arises in the area of tone detection is the presence of background noise. In certain communications applications, it may be known that there is no user speech or background noise that is added to the CPT 15 signal. For instance, when the calling party is an automated system, background noise from the calling end is very weak or not present. Similarly, when a called system detecting Dial, Ring and Busy tones when the called end is on-hook, there is generally no background noise or speech from the called end. In other 20 applications, it may be necessary to detect the tones in the presence of speech or background noise. Furthermore, band-pass filters and the traditional DFT computation are not reliable with tones distorted with Gaussian noise, impulse noise, speech signal, tone interruptions, time shifts between frequency components and 25 those having ambiguous transition time zones between two states.

This type of interference is very common in telephone networks where the transmission lines are subject to atmospheric conditions and an uncontrollable environment.

30 Thus, there exists a need in the industry to provide a tone receiver particularly well-suited to the detection of call progress tones being capable of a high degree of flexibility, being capable of maintaining high computational efficiency, being capable of providing a precise control over the time and frequency acceptance 35 and rejection bands, and being able to detect CPT tone within a reduced time delay.

Objects and Statement of the Invention

A principal object of the invention is to provide an improved
5 method and apparatus for performing cadence detection on a signal.

Another object of the invention is to provide an improved
method and apparatus for performing tone detection on a signal.

10 Another object of the invention is to provide an improved
method for performing logical processing on a signal.

Another object of the invention is to provide an improved tone
detection system.

15

As embodied and broadly described herein the invention
provides an apparatus for performing cadence detection on a signal,
said apparatus comprising:

- an input for receiving an input signal potentially
20 manifesting a certain cadence;
- a signal processing functional block coupled to said input
for receiving the input signal, said signal processing
functional block being operative to successively compute
confidence level values over time during a processing
25 period, a currently computed confidence level value being
indicative of a likelihood of existence of a certain
cadence in the input signal since a beginning of said
processing period, said processing period being
characterised by a variable duration;
- said signal processing functional block including an output
30 for generating an output signal indicative of the
confidence level value at the end of said processing
period.

35 For the purpose of this specification the expression

"accumulator" is used to designates a device used to sum numbers by adding its current content to an input value and then replacing its current value by the newly computed one. In mathematical terms to perform the operation $x = x + y$.

5

For the purpose of this specification the expression "complex accumulator" designates an accumulator where the arguments are of the form "a+ib" and where a and b are real numbers and $i = \sqrt{-1}$. Furthermore this device preferably stores the real and imaginary 10 parts of the result separately.

For the purpose of this specification the expression "complex multiplication" designates a multiplication where the arguments are of the form "a+ib" and where a and b are real numbers and $i = \sqrt{-1}$. 15 Furthermore a device implementing this operation preferably stores the real and imaginary parts of the result separately.

For the purpose of this specification the expression "cadence" is used to designate a pattern of regular or irregular pulses and 20 silences. In a specific example, the cadence of the fax calling tone is characterized by 0.5 sec ON; 3.0 sec OFF; 0.5 sec ON; 3.0sec OFF and so one.

For the purpose of this specification, the word "state" is 25 used to designate the condition of the signal in terms of certain attributes. In a specific example, attributes include "ON / OFF" conditions, frequency characteristics and duration characteristics.

In a preferred embodiment, a signal being detected contains 30 several states. Every state in the signal is characterized by a set of parameters. In a specific example, state parameters include the number of frequencies, the nominal frequencies, the frequency tolerance, amplitude levels of the frequencies, amplitude twist, state duration and other parameters that are constant during a 35 given state. Between two states of a signal, a transition zone can exist. In a most preferred embodiment of this invention the tone

detector is capable of detecting several tones of the type described above at the same time. Because there are common nominal frequencies for different tone, the preferred embodiment of this invention uses a common stage of quadrature processing (first stage 5 spectral processing) for the tones being detected. This allows a reduction in computations.

In a most preferred embodiment, the tone detection apparatus features a dual-stage spectral processing operation for detecting 10 the presence of tones in the signal. During the first stage the energy of the signal is computed over a plurality of signal sub-frames in the frequency bands of interest, each frequency band corresponding to a given tone. For each sub-frame this involves computing a DFT coefficient for each frequency band. The DFT 15 coefficients are computed in a phase-continuous fashion from one sub-frame to another. The phase continuity will allow the second stage to perform high frequency resolution computations at a low computational cost. In addition, during the first stage, the average signal level A over a sub-frame is computed along with the 20 energy D of the signal and sub-frame DFT coefficients. The results of the first stage are stored in buffers and to wait for further processing. During the second stage analysis, a second DFT is computed on the basis of segments using the results of the first 25 DFT computation. In other words, the spectral processing operation of tone detection apparatus performs a direct computation of the Discrete Fourier Transform (DFT) on short time sub-frames and then performs a second DFT computation on segments using the results of the first DFT computation. A segment is typically composed of about seven sub-frames. Adjacent segments may have overlapping 30 sub-frames to achieve the desired temporal resolution. Other size combinations are possible depending on the desired time and frequency resolution. The validation unit then receives the results of the spectral processing. In a preferred embodiment the validation unit comprises a logical processing unit and a cadence 35 processing unit. The logical processing unit performs a series of tests to determine if a tone is present in the signal. Preferably,

for each tone of interest, a separate logical processing unit is present in the tone detector. Each logical processing unit receives the data generated from the spectral processing module.

In a preferred embodiment, the logical processing unit determines whether the current segment of the signal satisfies the properties of the current state in the tone pattern being detected. In a preferred embodiment, this is performed by applying a series of tests to the spectral processing results. Some or all the following tests may be applied to the candidate frequencies: (i) a frequency tolerance test; (ii) a stability test; (iii) an SNR twist; (iv) a Power and twist test; (v) a pulse consistency test. In a specific example, for each tone a mask indicates which of these tests should be applied. The mask may be stored on a computer readable medium along with the other parameters of the tones. In a preferred embodiment, the output of the logical processing unit is a binary classification of the segment for each CPT tone as either a successful detection or an unsuccessful detection. Preferably, following the logical processing unit, a non-linear filtration unit processes the binary classification results in order to smooth out the output. In a specific example, a median filtration algorithm is used to smooth the binary classification of the segments. In addition to the logical processing unit, a cadence processing unit receives the result of the spectral processing unit and the logical processing unit. Preferably, for each tone of interest, a separate cadence processing unit is present in the tone detector. Each cadence processing unit receives the data generated from the spectral processing module and the logical processing module corresponding to the same tone of interest. In a preferred embodiment, the cadence processing unit verifies whether the timing pattern of the signal satisfies that of a specific tone. The cadence processing unit further includes a "timeout" feature that allows a rapid decision as to whether a tone cannot be detected with a minimum confidence within the remainder of the observation window. When a minimum confidence value cannot be obtained in the remaining observation window for a given tone, the cadence processing unit allows the tone detector to timeout before the end

of the observation window.

5 The use of the first DFT block with short time duration sub-frames enables to obtain a high temporal resolution for the signal.

As a specific example, suppose the signal is sampled at a rate of 8000Hz and that the time window is 20 samples. This permits a time resolution of:

10
$$\frac{20 \text{samples / subframe}}{8000 \text{samples / sec}} = 2.5 \text{ms / subframe}$$

On the other hand the spectral resolution is poor being only 400Hz in the example above. Hence, this stage allows a precise control over the tone duration evaluation.

15 The second DFT, obtained by using results computed in the first DFT on a complete segment enables us to obtain high spectral accuracy. Insuring the first DFT is phase continuous allows using the results directly in the second DFT without requiring a return 20 to the time domain signal. Taking the example described above and assuming that a segment is composed of 7 sub-frames, the frequency resolution becomes ~57Hz. This stage allows a precise control of the frequency acceptance and rejection bands. By changing the nominal frequencies where each of these two blocks computes the 25 DFT, this configuration can be adapted to suit nearly any signal.

In a preferred embodiment, the apparatus for performing tone detection suitable for detecting call progress tones comprises:

30 An anti-aliasing low-pass filter to eliminate the spectral portion of the analog signal that is not in the range of interest.

An analog to digital (A/D) converter which samples the incoming signal at a rate at least equal to the Nyquist rate (8000 Hz for a telephone network) and converts it 35 to a digital format such as PCM code.

5 A quadrature processing block that allows the system to substantially reduce the data stream with minimal loss of information as well as performs the first stage of spectral analysis. This processing block computes the DFT coefficients at candidate frequencies, the average signal level A and energy level D for each sub-frame of the signal.

10 A precision spectral processing block which computes precise results regarding the frequency deviation of the signal with respect to nominal frequencies and permits stringent control over the accept/reject frequency bands of the receiver. This is achieved by computing a second level DFT over a segment on the basis of the first level DFTs computed by the quadrature-processing block.

15 A logical processing block that compares temporal characteristics of the signals with pre-determined values as well as determines based on results from the quadrature and precision spectral processing blocks, if a proper tone has been detected. The logical processing block may comprise a filtering module to smooth out the 20 classification results.

25 A cadence processing block analyses the results of the logical processing block over a slightly longer period of time (generally in terms of seconds instead of msec for the other stages). It allows determining if the correct cadence or time pattern has been detected. This block is present mainly when the tone detector is used for CPT 30 tone detection. The cadence processing block further comprises a timeout feature allowing the tone recognition apparatus to timeout when a minimum confidence level cannot be reached within a given observation time window.

35 In a preferred embodiment, the tone detector may further comprise computer readable mediums including:

A digital sample buffer that accumulates the digitally sampled

incoming signal into sub-frames that will be used in future processing.

A plurality of frequency buffers, one for each analysed frequency, which accumulate the results of the first 5 processing stage into buffers representing a sequence of consecutive segments.

An average signal level buffer for storing the average signal level A computed for each sub-frame.

A signal energy buffer for storing the energy D of sub-frames 10 computed for each sub-frame.

A lookup table comprising the pre-computed sine and cosine values needed for the Discrete Fourier Transform (DFT) computation. This table is used in both the quadrature processing block and the precision spectral processing 15 block.

A tone parameter database storing parameter specifying the characteristics of each tone potentially detectable by the tone detection apparatus. Such characteristics may include the tests to be performed, rejection/acceptance 20 boundaries and other useful information.

More specifically, in a most preferred embodiment, the tone detection apparatus operates as follows. The apparatus receives an analog signal from the system. The analog signal is first low 25 passed filtered and then sampled in order to produce a digital signal. In the case of a telephone network application, the filtering is usually done at 4 kHz, since the frequencies of interest are in that range and therefore the sampling rate would be 8 kHz as directed by the Nyquist theorem. The digital samples . 30 are then stored in a buffer of size N that represents one sub-frame of the signal. The size of the sub-frame will determine the time resolution of the system. These samples are then transferred to the quadrature-processing block. There a DFT is computed on the sub-frames at each of the analysed candidate frequencies. A set 35 of parameters, which are simply the values obtained by performing a DFT on a sub-frame, is generated. There is one parameter for

each analysed frequency. These parameters in turn are stored, each frequency in a separate buffer. The average signal level A is also computed over a sub-frame and the result is stored in separate buffer. Also the energy D of the sub-frame is computed and the 5 result is stored in another separate buffer. Once this analysis has been performed on a plurality of sub-frames and the resulting parameters have been stored in buffers, these computed values are processed by the precision spectral processing stage, by the logical processing stage, and by the cadence processing stage.

10

The precision spectral processing is executed for each of the tones of interest. For each of these tones there are frequencies of interest (often two) on which the precision spectral processing is performed around the nominal value for the frequency components. 15 The analysis is computed on segments that are preferably composed of a few consecutive sub-frames. The purpose of this stage is to obtain power estimations for very narrow frequency bands and to determine if the frequency tolerance requirement was satisfied. Advantageously, an analysis is performed on $(2L+1)$ local 20 frequencies placed at regular intervals on both sides of a frequency that is closest to the nominal in a range determined by the specified frequency tolerance. Alternatively, the intervals are placed at irregular intervals. In a preferred embodiment, the specified frequency tolerance is stored in the tone parameter 25 database. The analysis is done by computing a weighted version of the DFT operation at each of the local frequencies and then applying magnitude and weighting operators. The weighting function is usually a time domain window such as a Hamming window centred about a frequency near the nominal. Energy values of the input 30 signal are found at this stage which are then supplied to the logical processing stage. The logical processing stage uses the values obtained from the previous stages at each of the analysed frequencies to compare the specifications of each tone over a given time window. Following this, a cadence processing unit analyses 35 the timing characteristics of the signal over a longer time window. If the specifications are met, information about the tone received

is sent to a controller station where the operation or connection is performed. In a specific example, information about the tone received is sent to a controller unit in binary format. In the event that some or all of the specifications have not been met, an 5 error may be reported. Alternatively, the erroneous sequence may be ignored.

In a preferred embodiment, the logical processing stage provides frequency validation of the signal and outputs a binary 10 classification of the segments as a successful tone detection or as an unsuccessful tone detection. In a preferred embodiment, the logical processing stage receives the results for the quadrature processing stage and the precision spectral processing stage. Preferably, for each tone of interest, a separate logical 15 processing unit is present in the tone detector and each logical processing unit receives the data generated from the spectral processing module. For each tone of interest, the logical processing stage performs a set of tests to determine whether specifications for the tone have been met. Preferably, for each 20 tone, the corresponding specifications are stored on a computer readable medium in the tone parameter database. In a preferred embodiment, for each tone of interest, a mask defines which tests are to be applied for the validation of the tone. Each test 25 results in a binary result indicating whether the segment being tested is a pass or fail. Hence, for multiple tests, a vector is outputted for each segment. The vector is then processed and the segment is classified as either a successful detection or a unsuccessful detection according to the test results. Optionally, 30 these classifications are stored in a buffer and processed by filtration stage. In a specific example, a median filtration algorithm is used. The filtration stage allows the elimination of variations in classification due to noise such as line noise, background noise, speech noise and impulse noise. The result of 35 the logical processing stage is processed by the cadence processing stage.

In a preferred embodiment, the cadence processing stage receives the results of the quadrature processing stage, the precision spectral processing stage and the logical processing stage. Preferably, for each tone of interest, a separate cadence processing unit is present in the tone detector. For each tone of interest, the cadence processing stage performs a timing validation test to evaluate whether the timing features of the signal conform to the specification of the tone. Preferably, for each tone the specifications are stored on a computer readable medium in the tone parameter database. Alternatively, each cadence processing unit is constructed for a specific tone. In a preferred embodiment, the tone detection apparatus provides a partial confidence feature that reports levels of partial confidence if the full cadence of a tone has not been qualified within a specified time, herein referred to as the observation window. The cadence processing stage tests the results and allows the system to time-out when a minimum confidence level cannot be reached within the observation window. In a preferred embodiment, the cadence processing operation is performed on the basis of segments. For a subframe that coincides with a segment interval, the timeout conditions are tested after the cadence validation has been performed. Each cadence processing unit in the cadence processing stage must timeout before the cadence processing stage as a whole can report a timeout tone indication. The condition that all cadence processing unit have timed-out is tested on a subframe interval level. In a preferred embodiment, each cadence processing unit may timeout under the following conditions:

- a) the minimum level of confidence cannot be reached within the remaining time in the observation window. A null confidence level indication is reported.
- b) The full duration of the observation window has been reached. A tone indication is reported with the confidence level equal to the counter of the current state in the cadence processing.

provides a method for performing cadence detection on a signal, said method comprising the steps of:

- receiving a signal potentially manifesting a certain cadence;
- successively computing confidence level values over time during a processing period, a currently computed confidence level value being indicative of a likelihood of existence of a certain cadence in the input signal since a beginning of said processing period, said processing period being characterised by a variable duration;
- 10 - generating an output signal indicative of the confidence level value at the end of said processing period.

As embodied and broadly described herein the invention provides a method for performing cadence detection on a signal, 15 said method comprising the steps of:

- receiving an input signal potentially manifesting a certain cadence;
- processing said signal to successively compute confidence level values over time during a processing period, a currently computed confidence level value being indicative of a likelihood of existence of a certain cadence in the input signal since a beginning of said processing period;
- 20 - controlling a duration of said processing period on a basis of the currently computed confidence level value.

25

As embodied and broadly described herein the invention provides an apparatus performing cadence detection on a signal, said apparatus comprising:

- an input for receiving an input signal potentially manifesting a certain cadence;
- a signal processing functional block for processing said signal to successively compute confidence level values over time during a processing period, a currently computed confidence level value being indicative of a likelihood of existence of a certain cadence in the input signal since a 30
- 35

beginning of said processing period;

- a duration control unit for controlling the duration of said processing period on a basis of the currently computed confidence level value.

5

As embodied and broadly described herein the invention provides a tone detection apparatus suitable for detection of call progress tones, a call progress tone being characterised by at least one frequency component and a timing behaviour defining a 10 certain cadence, said apparatus comprising:

- an input for receiving an input signal potentially containing a call progress tone, the signal being capable of being divided in a plurality of consecutive sections;
- a spectral processing unit for processing said signal to generate a plurality of sets of data elements, the sets of data elements providing spectral information about respective sections of the input signal;
- a frequency component processing unit coupled to said spectral processing unit for receiving sets of data elements and for processing the sets of data elements to output sets of classification data elements indicating whether a frequency component of a certain call progress tone exists in respective sections of the input signal;
- a cadence processing unit coupled to said frequency component processing unit for receiving and processing sets of classification data elements to compute over time successive confidence level values for the input signal during a processing period encompassing the sections of the input signal that correspond to the sets of classification data elements processed by the cadence processing unit, a currently computed confidence level value being indicative of a likelihood of existence of a certain cadence in the input signal since a beginning of said processing period, said processing period being characterised by a variable duration;
- said cadence processing unit including an output for

generating a signal indicative of the confidence level value at the end of said processing period.

5 As embodied and broadly described herein the invention provides a method for performing tone detection suitable for the detection of call progress tones, a call progress tone being characterised by at least one frequency component and a timing behaviour defining a certain cadence, said method comprising the
10 steps of:

- receiving an input signal potentially containing a call progress tone, the signal being capable of being divided in a plurality of consecutive sections;
- processing said signal to generate a plurality of sets of data elements, the sets of data elements providing spectral information about respective sections of the input signal; processing the sets of data elements to output sets of classification data elements indicating whether a frequency component of a certain call progress tone exists in respective sections of the input signal;
- processing said sets of classification data elements to compute over time successive confidence level values for the input signal during a processing period encompassing the sections of the input signal that correspond to the sets of classification data elements processed by the cadence processing unit, a currently computed confidence level value being indicative of a likelihood of existence of a certain cadence in the input signal since a beginning of said processing period, said processing period being characterised by a variable duration;
- generating a signal indicative of the confidence level value at the end of said processing period.

provides a tone detection apparatus suitable for detecting call progress tones, a call progress tone being characterised by a sequence of states, said apparatus comprising:

- an input for receiving an input signal potentially containing a call progress tone, the signal being capable of being divided in a plurality of segments;
- a spectral processing unit for processing said signal to generate a plurality of sets of data elements, the sets of data elements providing spectral information about respective segments of the input signal;
- a logical processing unit coupled to said spectral processing unit for receiving and processing the sets of data elements, said logical processing unit being operative to compute over time successive classification elements for respective segments of the input signal, each of the successive classification elements indicating whether the properties of the signal during the time segment match the properties of a certain state of a certain call progress tone;
- said logical processing unit including an output for generating a result signal representative of the classification element computed by said logical processing unit.

25

As embodied and broadly described herein the invention provides method for detecting call progress tones, a call progress tone being characterised by a sequence of states, said method comprising the steps of:

- receiving an input signal potentially containing a call progress tone, the signal being capable of being divided in a plurality of segments;
- processing said signal to generate a plurality of sets of data elements, the sets of data elements providing spectral information about respective segments of the input signal;
- processing the sets of data elements to compute over time

successive classification elements for respective segments of the input signal, each of the successive classification elements indicating whether the properties of the signal during the time segment match the properties of a certain state of a certain call progress tone;

5 generating a result signal representative of the classification element computed by said logical processing unit.

10 As embodied and broadly described herein the invention provides a tone detection system for use in a telecommunication network comprising an apparatus for performing cadence detection on a signal.

15 Brief description of the drawings

These and other features of the present invention will become apparent from the following detailed description considered in connection with the accompanying drawings. It is to be understood, 20 however, that the drawings are designed for purposes of illustration only and not as a definition of the limits of the invention for which reference should be made to the appending claims.

25 Fig. 1 shows a high-level block diagram of a prior art tone receiver used in the context of Multi-Frequency (MF), Dual Tone Multi-Frequency or call progress tones (CPT).
Fig. 2 shows an example of a prior art spectral processing unit that uses bandpass filters to analyse the incoming signal.

30 Fig. 3 shows a high-level block diagram of a preferred embodiment of the tone detection apparatus constructed in accordance with the present invention.
Fig. 4 shows a detailed block diagram of the quadrature-processing block of the tone detection apparatus of figure 3.

Fig. 5 shows a block diagram of the DFT computation module of the quadrature processing block.

Fig. 6 shows a block diagram of a processing block, for computing exponential values using a lookup table of the apparatus, in accordance with the invention.

Fig. 7 shows a detailed diagram of the preferred embodiment of the precision spectral processing block of the apparatus constructed in accordance with the invention.

Fig. 8 and 8a shows a block diagram for embodiments of the validation unit.

Figure 8b shows a block diagram for an embodiment of the testing unit of the logical processing block.

Fig. 9 shows a flow diagram of an embodiment of the classification unit of the logical processing block.

Fig. 10 shows a block diagram of the filtration unit of the logical processing block.

Fig. 11 and 11a show flow diagrams of the cadence processing block.

Fig. 12 shows an apparatus for tone detection in accordance with the spirit of the invention.

20

Description of a preferred embodiment

The present inventors have made the unexpected discovery that by performing a first DFT on a short time window (sub-frame) and 25 a second DFT on a larger window (segment), both high time and frequency resolution can be obtained while requiring a minimal amount of computation. Furthermore, by applying a non-linear filtration algorithm to the results of the logical processing operation, accrued robustness to noise is obtained. Finally, by 30 allowing the system to time-out when a sufficient level of confidence cannot be reached within a given observation window during the cadence processing stage, an improvement in the response-time of the system can be obtained. A tone detection apparatus implementing these inventive principles can be adapted 35 to various signalling conventions by simply modifying a pre-

determined set of parameters. The result is a robust, highly efficient tone detection system that can be easily adapted to recognise current and future signalling convention by simply changing the necessary parameters.

5

In a most preferred embodiment of this invention, the tone detection apparatus is integrated into a communication channel, such as one that could be used in a telephone network, that enables the accurate detection and decoding of Call Progress Tones (CPT).
10 Call progress tones, also called audible tones, are used to inform users and operators of the system about the progress or disposition of the telephone call they are attempting. CPT tones include the dial tone, audible ring, line busy, reorder, special service information tones (SIT), recall dial tone and many others
15 represented as Multi-Frequency signals having a complex cadence. Traditionally, standards governing the CPT tone have been very lax. Typically, we differentiate CPT tone more on the basis of their cadence than on stringent frequency and time accept/reject rules in contrast to the case for MF and DTMF tones where precise
20 specifications are given. In a typical interaction, a transmitter from a calling office initiates a call progress tone sequence. The CPT receiver monitors the communication channel for tones. The CPT receiver first performs an analog to digital conversion of the signal and proceeds in the spectral and temporal analysis of the
25 signal. The spectral analysis is performed by first computing a DFT as well as the average level and energy of a sub-frame of the sampled signal at the quadrature processing stage. Following this, the precision spectral processing stage performs a second DFT on the basis of the first DFT computation in the quadrature processing
30 stage. Following this computation, the results of the quadrature processing stage and the precision spectral processing stage are sent to the logical processing block and cadence processing block which evaluate if some predetermined criteria have been met and if the spectral and temporal requirements have been attained. If a
35 valid tone is detected, the corresponding information is sent to a controller that performs a predetermined operation such as

connection or billing.

The table below shows a few common Call progress tones (CPT) :

5

f1/f2 Hz	0	440	480	620
350		Dial Tone/ Stutter Dial Tone		
440	Call Waiting/ Variations		Ringing	
480				Busy/ Reorder

The table below illustrates the frequency and timing behaviours of common CPT tones. Note that Dial, Ring, Busy and Reorder are dual-tones (i.e. 2 frequencies) while the SIT is a 10 concatenation of three mono-tones (i.e. 1 frequency).

Tone Type	Freq. Components (Hz)	Timing Information
Dial	350.0 + 440.0	Steady
Ring	440.0 + 480.0	Cadence of 2.0s ON, 4.0s OFF
Busy	480.0 + 620.0	Cadence of 0.5s ON, 0.5s OFF
Reorder	480.0 + 620.0	Cadence of 0.25s ON, 0.25s OFF
SIT	913.8, 1370.6, 1776.7	274ms, 274ms, 380ms

15 In a most preferred embodiment of the present invention, the tone detection apparatus shown in figure 3 receives an analog signal that is then processed by a multi-step operation.

Anti-Aliasing Low-pass Filter

The first step, usually referred to as the anti-aliasing low-pass filter 105, is used to eliminate frequencies outside the range 5 of interest thereby eliminating or reducing the effect of aliasing when the continuous signal is converted to digital format. By the Nyquist theorem, the cut-off frequency of the filter should be half that of the sampling frequency. In the case of a telephone network application, the cut-off is generally about 4000Hz. This operation 10 is very well known in the art of signal processing.

Analog to Digital Converter

The second step, usually referred to as the analog to digital converter 106, consists of sampling the incoming analog signal to 15 produce a digital version of it. Sampling is usually performed at a rate at least equal to the Nyquist rate such as to avoid the possibility of aliasing. In the context of a telephone network this rate is 8000 samples/second. Typical digital representations that could be used in the context of a receiver include Pulse Code 20 Modulated signals (PCM), differential PCM (DPCM) and Adaptive Delta Modulation (ADM). Many coding schemes exist and are used for various reasons such as efficiency, compactness, simplicity and others. The most preferred embodiment of this invention uses the PCM coding scheme. The analog to digital conversion process is 25 well known in the art of signal processing and telecommunications. Note here that in the case the input signal is digital, this A/D converter 106 and the low-pass filter 105 are not required. Further information on PCM and other coding techniques can be obtained on this topic from standard textbooks on signal processing 30 such as in "Discrete-Time Processing of Speech Signals" by Deller, Proakis and Hansen, Macmillan Publishing Company New York 1993 whose content is hereby incorporated by reference. The digital samples obtained from the A/D converter 106 are then stored into sub-frames on a computer readable medium 108. Once a predetermined 35 number of samples have been collected, these samples are passed on

to the next processing stage. The number of samples N in the storage buffer depends on the frequency and time resolution desired by the system. Since at this stage we are mainly concerned with high time resolution, short time windows are used. In an embodiment of this invention used for CPT detection, we use sub-frames of 16 samples (2.0ms) for CNG tones and sub-frames of 32 samples (4.0 ms) for other CPT tones.

Spectral Processing

10 The third step, called spectral processing 301, analyses the spectral properties of the input signal. In a preferred embodiment, the spectral processing unit 301 comprises two functional blocks namely the quadrature processing block 300 and the precision spectral processing block 304. The spectral 15 processing unit 301 further makes use of computer readable mediums containing a first level DFT storage unit 302, an average signal level storage unit 350, an energy value storage unit 352, and a set of tone parameters 308. The computer readable mediums may be any suitable devices for storing data such as a disk, NVRAM, ROM or 20 other. Therefore, for the different classes of signals (MF, DTMF, MF-R2, and CPT) the main differences in the spectral processing step are the parameters 308 such as the nominal frequencies and the levels of tolerance that may be supplied for each different signal class.

25

The quadrature processing block 300 shown in figure 4 performs the preliminary filtration of the signal. In a preferred embodiment, the quadrature processing block 300 comprises three functional modules, namely a DFT computation module 450, a signal 30 level computation module 452, and a sub-frame energy computation module 454. The DFT computation module 450, which is shown in details in figure 5, performs a DFT computation at each frequency of interest on a sub-frame of the digital signal. It consists of N_f structurally identical DFT channels where N_f is equal to the 35 number of analysed frequencies. This module 450 achieves the high

time resolution required for accurate tone detection. The spectral analysis is performed on the digital samples stored in the buffer 108 and the DFT coefficients are obtained at this stage and stored in the first level DFT storage unit 302. The DFT is well known in the art of signal processing and basic principles can be found in signal processing text books such as "Discrete-Time Signal Processing" by Oppenheim and Shafer, Prentice Hall series, 1989 whose content is hereby incorporated by reference. In a specific example, the DFT coefficients are computed by using the following equation:

$$(1) \xi_k(r) = \sum_{i=rN}^{rN+N-1} x_i \exp\{j2\pi f_k i T + \Phi_k\}$$

for i = rN to rN+N-1
 i.e. over one sub-frame
 $j = \text{sqrt}(-1)$

15

In the above equation: x_i designate the PCM sample at time i; r is the sub-frame number; k is the index of the frequency analysed; f_k is the frequency analysed; T is the reciprocal of the sampling rate and Φ_k is the starting phase of the current sub-frame. The phase component Φ_k is used at this stage in order to permit phase continuity between sub-frames and to allow parameters computed using sub-frames to be combined without requiring the recomputations of the DFT. In a specific example, when computing the DFT coefficients for a given sub-frame, the variable Φ_k for use in the above formula is set to the value of the final phase of the previous sub-frame. This feature enables to provide phase continuity between the sub-frames.

A specific example of a device to carry out the DFT computation is depicted in figure 5. The device comprises:

Complex multipliers 402 404 406, one for each of the analysed frequencies.

Complex accumulators 408 410 412, one for each of the analyzed frequencies. In figure 5, these blocks 408 410 412 indicate that the results of the multiplication 402 404 406 are summed over one sub-frame.

5

Following this, the computed values 414 416 418 are stored each in a separate buffer 420 422 424 part of the first level DFT storage unit 302 where they are stored for use by the second stage spectral processing computations. In a preferred embodiment, the 10 size of each of the buffers is equal to at least the total number of sub-frames in a segment. If the receiver is designed to accommodate different segment durations, the size of the buffer is at least equal to the maximum segment duration. In a specific example, the buffers 420, 422 and 424 are circular buffers. Note 15 that the illustration in figure 5 shows only 3 channels for the sake of simplicity. In the case of a receiver detecting MF, DTMF, CPT or any other signalling, the number of channels would be equal to the number of frequencies being analysed.

20 The computation of the complex multiplications 402 404 406 requires a more detailed explanation. In a preferred embodiment, in order to speed up the computations and hence favour the real-time characteristic of the invention, a look-up table is used to reduce the computational load by pre-computing a set of values and 25 storing them in a permanent or temporary computer readable medium.

This reduces the complicated computation of an exponential into the computation of addresses in a look-up table. Furthermore, in order to satisfy the phase continuity criteria of the DFT computation for this invention, care must be taken to properly set 30 the phases ϕ_k in the exponential values in order to achieve this goal. This is done by continuing the initial phase of a sub-frame DFT computation from the final phase of the previous sub-frame DFT computation. Figure 6 shows this computation, as it would be performed in a preferred embodiment of this invention. This 35 modules comprises:

A read-only-memory (ROM) unit 500 where the lookup table of previously computed values is stored.

An index register 502 used to store the last address in the lookup table of the frequency analyzed. In order to provide phase continuity, both the real and imaginary part of the computation are stored and updated separately.

A modulo M adder 504 used to compute the address in the lookup table.

10 A δ register 506 used to contain the step size for each of the frequencies analyzed.

An accumulator 508 used to sum intermediate results until a complete sub-frame has been analyzed.

15 The principles of this computation are well known in complex variable mathematics and in basic signal processing theory where an exponential can be expressed as a complex combination of Sine and Cosine waves. In mathematical terms:

$$(2) e^{j\Phi} = \cos(\Phi) + j\sin(\Phi)$$

20 In the preferred embodiment of the invention, the sine values are stored in a lookup table 500 of size M which represents 360 degree, or one period of a sine wave, and which allows a frequency resolution of f_s/M in the case where the sampling frequency is f_s Hz. The cosine values are not stored in this table since they can 25 be extracted from the sine value by shifting the angle by 90 degrees or, alternatively by shifting the indices in the lookup table by $M/4$. Therefore, with the above description in mind, equation 1 may be rewritten as:

$$(3) \xi_k(r) = \sum_{i=rN}^{rN+N-1} x_i S[\{i\delta(k) + \text{IndexCosine}(k)\} \bmod M]$$

$$+ j \sum_{i=rN}^{rN+N-1} x_i S[\{i\delta(k) + \text{IndexSine}(k)\} \bmod M]$$

30 where

$$S(m) = \sin(2\pi m / M) \quad m = 0, \dots, M-1 \quad i.e. m \text{ is the index of the lookup table}$$

r is the subframe number

N is the size of the subframe

(4) $\delta(k)$ is the address step in the table for the k'th frequency analysed

IndexCosin e (k) is the last address pointer to the lookup table of the frequency
in the previous buffer for the real part of equation 3

IndexSine(k) is the last address pointer to the lookup table of the frequency
in the previous buffer for the imaginary part of equation 3

The step size $\delta(k)$ is computed by dividing the analyzed frequency by the frequency resolution. As a concrete example, let us consider CPT tones where the nominal frequencies are located at {350, 440, 550, 940, 1400, 1480, 1800}. If the sampling rate is 8000Hz and using a lookup table of 800 entries, the frequency resolution is 10Hz and the following values of $\delta(k)$ would be obtained {35, 44, 55, 94, 140, 148, 180} each value corresponding to a specific nominal frequency.

The IndexCosine(k) and IndexSine(k) values shown in the previous equations are computed recursively to reflect the current phase of the computation. As illustrated in figure 6, the following computation involving the modulo M adder 504 and the index register 502 is performed:

$$(5) \quad \begin{aligned} \text{IndexCosine}(k) &= [\text{IndexCosine}(k) + \delta(k)] \bmod M \\ \text{IndexSine}(k) &= [\text{IndexSine}(k) + \delta(k)] \bmod M \end{aligned}$$

Where IndexCosine(k) is initialized to M/4 to reflect the 90-degree phase shift of the cosine computation and IndexSine(k) is initialized to 0.

The organization described above allows continuous phase by using modulo M addressing in the look-up table and by storing real and imaginary part of the result separately. The organisation of the lookup table may vary greatly between different implementations and manners different from the one presented here do not detract from the spirit of the invention as long as the DFT computation is

phase continuous. Continuity of phase allows the combination of the parameters computed in the sub-frames to be combined in later processing.

5 Preferably, the quadrature processing unit 300 also computes the average level of the signal over one sub-frame in module 452 as well as the energy value over one sub-frame in module 454. Calculating the average level and the energy of a signal is well known in the art of signal processing. Mathematically, module 452
10 this calculation may be expressed as follows:

$$(6) \quad A = \frac{1}{N} \cdot \sum_{i=0}^{N-1} x(i)$$

and module 454:

$$(7) \quad D = \frac{1}{N} \cdot \sum_{i=0}^{N-1} x(i)^2$$

15 In the above equations, A is the average level of the signal in a given sub-frame and D is the energy value over one sub-frame. Computing such equations in the art of signal processing is well known in the art to which this invention pertains. In a specific example, the equations are computed with dedicated hardware such as DSP chips. In another specific example, a multipurpose digital computer is used to implement such equations. The values computed
20 here are stored on a computer readable medium in any data suitable structure. The values of A are stored in the signal level storage unit 350 and the values of D are stored in the energy value storage unit 352. In a specific example, the signal level storage unit 350 and the energy values storage unit 352 are two circular buffers of
25
30 a suitable size.

Another block in the spectral analysis stage 301 is the precision spectral processing block 304. The purpose of this stage

is to achieve high frequency resolution in order to provide precise control of the accept/reject bands. The DFT parameters (ξ) computed in the quadrature block 300 are stored in N_f buffers for the duration of one segment where N_f is the number of frequencies analysed. In the preferred embodiment of this invention, the size of the segment is seven sub-frames. However, shorter or larger segments may be used to increase the frequency resolution of the system without detracting from the spirit of the invention. As a variant, the segments can also be made to overlap by including one or more of the last sub-frames composing the segment at the beginning of the following segment. By maintaining phase continuity in the sub-frame DFTs we can perform more precise and more robust processing than the traditional approaches without a major cost in computation. The general scheme of the precision spectral processing block 304 is shown in detail for one analysed frequency in figure 7. In the preferred embodiment of this invention this block comprises:

Complex multipliers 600, one for each of the local $2L+1$ frequencies near the nominal frequency being evaluated.

Complex accumulators 602, one for each of the local $2L+1$ frequencies near the nominal frequency being evaluated.

Magnitude square evaluators 604, one for each of the local $2L+1$ frequencies near the nominal frequency being evaluated.

Real multipliers 606, one for each of the local $2L+1$ frequencies near the nominal frequency being evaluated. A device such as a multiplexor 608 used to select the position of maximum amplitude amongst $2L+1$ entries.

The precision spectral processing block computes DFTs based on the results of the DFT produced by the quadrature block. It computes these DFTs at evenly spaced $2L+1$ frequencies about the frequency of interest and uses complex weights to define local frequencies and frequency resolution. In the preferred embodiment of this invention, a value of $L = 2$ has been found to yield satisfactory results and hence a DFT is computed at 5 local

5 frequencies. In a specific example, a Hamming window in the time domain has been used to give different weights to certain frequencies. Other windows such as the Bartlett window or no window at all may be used without detracting from the spirit of the invention. It must, however, be noted that not using a weight window will reduce the frequency accuracy of the system by not giving preference to any particular frequency in the acceptance band so a window weighing preferentially frequencies near that of interest is preferable. Mathematically, the operation performed 10 can be expressed as follows:

$$(8) \quad A_k(l) = \alpha_k(l)E_k(l)$$

location of maximum near $f_k = \text{MAX}_k[A_k(-L), \dots, A_k(0), \dots, A_k(L)]$

15 where:

$$(9) \quad E_k(l) = \left| \sum_{p=0}^{N_T-1} \xi_k(p) * w_k(l, p) \right|^2$$

$$\text{Emax} = \text{MAX}_k[E_k(l)]$$

where N_T is the total number of sub-frames in a segment and Emax is the power at the frequency of interest which has the strongest power.

20

$$(10) \quad \begin{aligned} F_k(l) &= f_k(l) - f_k \\ w_k(l, p) &= w(p) \exp\{j2\pi F_k(l)pT_m\} \\ &\text{where } w(p) \text{ is a Hamming window} \\ p &\text{ is the sub-frame index in a segment} \\ T_m &\text{ is the duration of a sub-frame (2.5ms for 20samples at 8kHz)} \\ l &\text{ is the index of the local frequency } [-L, \dots, 0, \dots, +L] \\ f_k &\text{ is the value of the nominal frequency} \\ f_k(l) &\text{ is the value of a local frequency} \end{aligned}$$

The results of equations 8 and 9 ($A_k(l)$, $E_k(l)$) and the location of their maximum values, are power estimations for narrow frequency bands about the nominal frequencies of interest.

Mathematically equation 8 represents the magnitude squared of the weighted DFT over one segment evaluated at local frequencies about the frequency of interest and weighted by $\alpha_k(l)$. The matrix of $\alpha_k(l)$ values is selected such that the spectral windows obtained by 5 multiplying the energy estimates intersect at the points determined by the frequency tolerance. The computation of $A_k(l)$ and of the maximum of the values obtained allows us to determine the position of the maximum amplitude value with accuracy. In the preferred embodiment of this invention, a vector is used to indicate which 10 bands are acceptable for having maximum amplitude and which are not. The matrix $\alpha_k(l)$ may be stored on a computer readable medium in the tone parameter database 308 accessible by the spectral processing blocks 300 304.

Validation Unit

15

In a preferred embodiment, the validation unit provides logical / cadence processing pairs, one for each of the tones of interest. As shown in figure 8a, there is one logical / cadence pair 850 852 854 856 for each tone of interest. The description 20 below is directed to a single logical / cadence processing pair.

Those skilled in the art will readily see how this may be applied to the other logical / cadence processing units.

As shown in figure 8, following the spectral processing unit 25 301, the signal is processed by the logical 758 and cadence processing units 756 in the validation unit. The logical processing block 758 produces a signal Dout that is inputted to the cadence processing block 756. The cadence processing block 756 outputs a confidence level indicative of level of success attained in the 30 cadence detection process. The cadence processing block 756 also updates the state of the signal. This state is used during the analysis of the signal in the logical processing block 758. The logical and cadence processing units will be described separately.

The validation unit 306 determines for each candidate tone, based on the information obtained from the previous quadrature 300 and precision spectral processing blocks 304, if a valid tone has 5 been detected. The validation unit 306 is different for each class of signals. For instance, in the case of MF and DTMF signalling, two and only two frequencies must be above the energy threshold while certain CPT tone are composed of single frequency tones. Furthermore, MF signalling the acceptance bands are $\pm 1.5\% \pm 5\text{Hz}$ 10 while for the DTMF the acceptance band is only $\pm 1.5\%$. CPT tones frequency tolerance vary widely in the acceptance tolerance depending on the application.

In addition to evaluating the information supplied by the 15 spectral processing stage, this block evaluates the temporal characteristics of the signal. In the case of MF and DTMF signals this temporal analysis is limited to short time duration signals typically in the range of 10ms to 40ms. In the case of CPT tones, a cadence processing operation compares the received cadence with 20 a set of pre-determined values. The cadence processing will be described later on in the specification. Once either a valid tone or no tone has been detected, the result is sent to another device such as a controller 116 that uses the decoded information. Specifications for tones may be found in standards publications 25 such as BellCore.

Here we will present a version of the logical processing block applicable to CPT tones. This design can be easily extended, although not directly applied, to other signalling modes. In a 30 preferred embodiment, as shown in figure 8, the logical processing unit can be divided into a testing stage 750, a classification stage 752, and a non-linear filtration stage 754. The testing stage 750 receives the results of the spectral processing 301 and the parameters from the tone parameter database 308.

performs the following series of tests in order to determine if the current segment satisfies the spectral properties of the tone:

- i) a frequency tolerance test 800;
- ii) a stability test 802;
- 5 iii) an SNR twist test 804;
- iv) a Power test and twist test 806;
- v) a pulse consistency test 808.

Preferably, each tone has a subset of the tests listed above 10 that must be performed in order to validate the tone. In a specific embodiment a test mask identifies for each CPT tone which tests are to be used. For example, the mask "10100" could indicate that test (iii) and (v) are to be performed with the digit "1" indicating the presence of a test and the digit "0" the absence of 15 a test. Other means for selecting the tests to be performed may be used here without detracting from the spirit of the invention.

Preferable, tests (i), (ii), (iii) and (v) are performed and test (iv) is selectively applied depending on the tone state to be detected. In a specific example of the busy tone, it may not be 20 desirable to apply the power and twist test. More specifically, the busy tone may either be a dual tone or a modulated tone depending on the unit generating the tone. If the tone detector want to be able to detect both instance of the busy tone, the power 25 and twist test is omitted in order to be able to successfully recognize both the dual tone and the modulated tone.

Frequency tolerance

In a preferred embodiment, the frequency tolerance test unit 30 800 determines if the frequency deviation from the nominal is within a pre-determined bound. The frequency deviation from the nominal can be evaluated by simply comparing the position of maximum amplitude computed by the precision spectral processing block 304 in equation 8 and comparing it to some pre-determined 35 boundary values in the tone parameter database 308. If the position of maximum amplitude is within the boundary, the test is

successful. The test is unsuccessful otherwise. In the case of dual tone, this frequency tolerance test may be performed only on the two frequencies of the candidate tone in order to minimize the computations. In a preferred embodiment, a signal is outputted to indicate if the test was successful. In a specific example, a digital signal is outputted from the frequency tolerance test unit 800 with "1" indicating success and "0" indicating failure.

Stability test

10

In a preferred embodiment, the stability test unit 802 tests that the energy of the strongest frequency component does not vary excessively from one segment to the next. The permissible level of variation is specified and may be stored on a computer readable medium in the tone parameter database 308. The energy of a frequency component was computed in equation 9 of the specification. For the reader's convenience, equation 9 is reproduced below.

$$(9) E_k(l) = \left| \sum_{p=0}^{N_T-1} \xi_k(p) * w_k(l, p) \right|^2$$
$$E_{\max} = \max_k [E_k(l)]$$

20

Where E_{\max} is the energy of the strongest frequency component on the current segment. If the value of E_{\max} is within a specified boundary, the test is successful. If E_{\max} lies outside the specified boundary, the test is considered to have failed.

25 Mathematically, this operation can be described as follows:

$$(11) E_{\max_previous} \times (1 - deviation) < E_{\max} < E_{\max_previous} \times (1 + deviation)$$

where $E_{\max_previous}$ is the energy of the previous segment and 30 $deviation$ is the percentage value of the allowed change in energy from one segment to the next. In a preferred embodiment, a signal is outputted to indicate if the test was successful. In a specific

example, a digital signal is outputted from the stability test unit 802 with "1" indicating success and "0" indicating failure.

SNR twist test

5

In a preferred embodiment, the SNR twist test unit 804 tests that the power of the strongest frequency component of interest constitute a minimum percentage of the total power of the signal.

A value for the minimum percentage is specified for each tone of 10 interest in the tone parameter database 308. In a preferred embodiment this percentage is stored as the parameter Twist1 on a computer readable medium.

Mathematically, the operation performed is as follows:

15

$$(12) \quad \begin{aligned} D_w &= \sum_{n=0}^{N_T-1} D(n) \cdot w(n) \\ A_w &= \sum_{n=0}^{N_T-1} A(n) \cdot w(n) \end{aligned}$$

$$(13) \quad \begin{aligned} E_{total} &= D_w - A_w^2 \\ E_{max} &> E_{total} \times \text{Twist1} \end{aligned}$$

20 where an N_T is the number of sub-frames in a segment, $A(n)$ is the average signal level of sub-frame n within a segment, $D(n)$ is the energy value of sub-frame n within a segment, and $w(n)$ is a weight window. If inequality 13 is satisfied, the test is successful. Otherwise the test has failed. In a specific example, 25 a Hamming window has been used to given different weights to certain sub-frames within a segment. Mathematically, we can express the window $w(n)$ as follows:

$$(14) \quad W(n) = \frac{\{0.54 - 0.46 \cdot \cos[\pi \cdot (n - B) / B]\}}{N_T}$$

$$B = \frac{N_T - 1}{2}$$

Other windows such as the Bartlett window or no window at all may be used without detracting from the spirit of the invention.

5 In a preferred embodiment, a signal is outputted to indicate if the test was successful. In a specific example, a digital signal is outputted from the SNR / twist unit 804 with "1" indicating success and "0" indicating failure.

10 Power and twist test

In a preferred embodiment, the Power and twist test unit 806 applies a combined power and twist test. In a preferred embodiment, these two tests are simultaneously performed in order 15 to improve the computational efficiency of the system. The execution of these two tests in combination or separately does not detract from the spirit of the invention. The power in each frequency of interest should satisfy a minimum absolute level. To test that the maximum twist between frequency components does not 20 exceed the tolerance, the power of each frequency component must satisfy a minimum threshold level relative to the power of the strongest component. The minimum absolute level and the permissible twist are specified as parameters in the tone parameter database 308. In a specific example, these parameters are stored 25 on a computer readable medium. In a typical interaction, a varying threshold is computed as follows:

$$(15) \quad \text{Threshold} = \max \{\text{minimum absolute level, } E_{\text{max}} \cdot \text{Twist}\}$$

30 where Twist is specified parameter defining the maximal twist between powers of frequency components within a tone. For example if Twist = -10 dB = 0.1 it means that the powers of the component frequencies can be as one is to 10. The value of the Twist

parameter is application specific. If the power of each frequency component is greater or equal to the threshold, the test is successful. If the power of each frequency component is less than the threshold, the test has failed. In a preferred embodiment, a signal is outputted to indicate if the test was successful. In a specific example, a digital signal is outputted from the Power and twist test unit 806 with "1" indicating success and "0" indicating failure.

10 In a preferred embodiment, a segment pulse ID variable stores a representation of the frequencies present in the current segment. In a specific example, the segment pulse ID is a bit vector with each corresponding to a frequency of interest. The bits of the segment pulse ID corresponding to frequencies with energies above 15 a pre-determined threshold are set.

Pulse consistency test

20 In a preferred embodiment, every state of the signal is characterized by a set of parameters. For each tone state State = 1, ..., Nstate there is a parameter VDigit(State) describing the frequency components present during a given state. The cadence processing unit updates the value of the "State". The cadence unit 25 is described later in the specification. In a specific example, the parameter VDigit(State) is a bit vector, where each bit corresponds to one frequency of the tone. If a bit is set, the corresponding frequency should be present during the segment for detection to be successful. For example, for SIT we have three 30 frequencies and three states. For the SIT, the following bit assignment can be used:

1. 950 Hz => bit0
2. 1400 Hz => bit1
3. 1800 Hz => bit2

35

The three states are:

1. Vdigit(1)= {001}
2. Vdigit(2)= {010}
3. Vdigit(3)= {100}

5 In a preferred embodiment, the pulse consistency test unit 808 checks if the current segment is consistent with the current state. More specifically, the value VDigit[State] is compared with the segment pulse ID assigned to the current segment. If the two values match, this test is passed. For signals in which there is 10 more than one tone state, such as the SIT signal which has three tone states with differing central frequencies, this test detects the transition from one state to another. In a preferred embodiment, a signal is outputted to indicate if the test was successful. In a specific example, a digital signal is outputted 15 from the consistency test unit 808 with "1" indicating success and "0" indicating failure.

Classification

20 In a preferred embodiment, the success or failure of each test is recorded in a bit vector.

The bit vector is then inputted to the next stage of the 25 logical processing unit namely the classification stage 752. This stage provides a binary classification in which the classification "1" indicates that in the current state the detection is successful. Successful detection means that either:

- (i) the current state is an ON state and the current segment 30 is consistent with this state, or
- (ii) the current state is an OFF state and the current segment satisfies the spectral properties of one of the ON states.

The classification "0" indicates that for the current segment the 35 detection was unsuccessful. Unsuccessful detection means:

- (i) the current state is an ON state and the current segment

is inconsistent with this state, or

(ii) the current statement is an OFF state and the current segment does not satisfy the properties of any ON state.

5

The classification is performed by analysing the results of the five tests recorded in the bit vector. The test mask indicates for each tone which test must be considered. As shown in figure 9, the classification is performed in a number of steps.

10

As a first step, the state VDigit[State] is checked to see if the current state it is an OFF state 950. If this test is answered in the negative, then a test is made to see if all the required tests are passed 952 by the current segment. This is done by 15 comparing the results of the test passed as recorded in the bit vector with the test mask. In a specific example, this is performed by checking the following condition:

Bit vector & test mask = test mask

20

where "&" denotes the bitwise AND function. If test 952 is answered in the positive, the segment is classified as a successful detection 954. If test 952 is answered in the negative, the segment is classified as an unsuccessful detection 960. If the state 25 VDigit[State] is a OFF, then condition 950 is answered in the negative and condition 956 is evaluated. Condition 956 checks if the state of the segment satisfies any of the ON states. For the current segment to satisfy this condition, any of the tests specified in the test mask must fail. Logically, the following 30 expression is tested:

Bit vector & test mask = test mask & PAUSE vector

In a specific example where "1" denotes test to be performed, 35 the PAUSE vector is 11110 indicating that the consistency test is to be omitted. Other suitable tests may be used without detracting

from the spirit of the invention. If the test succeeds, condition 956 is answered in the positive and the segment is classified as a successful detection 958. If the test fails, the segment is classified as an unsuccessful detection 960. In a preferred 5 embodiment, the OFF state is denoted by the binary digit "0".

The invention further provide a method to smooth the classification results in order to produce an output signal with less variation than the signal composed by the classification 10 results. Optionally, once the segment has been classified, the results are stored on a computer readable medium, and a set of classification segments is processed by the non-linear filtration stage 754. In a preferred embodiment a non-linear filtration algorithm is applied to the classification results. In a specific 15 example, a median filtration algorithm is used. Figure 10 shows an apparatus for implementing the median filtration algorithm. A buffer 1000 stores the Z last classification results. In a preferred embodiment, the length Z of the median filter is a prescribed parameter. The buffer is a shift register. The Z last 20 classifications are summed by an adder 1002. In a specific example, the outputs of the shift register 1000 are the inputs of the adder 1002. The output of the adder 1002 is equal to the number of ones in the buffer 1000. The output of the adder is compared to a threshold value by a comparator 1004. In a specific 25 example, the output of the adder 1002 is the input of the comparator 1004 which compares the calculated value to $(Z-1)/2$. If the output of the adder is greater than $(Z-1)/2$, then the comparator 1004 outputs "1", else the comparator 1004 outputs "0".

30 The output of the comparator is then processed by an selective inverter 1006. The selective inverter 1006 receives as an input the output of the comparator as well as the current state. If the current state $V_{digit[State]}$ is an OFF state, the output of the comparator is inverted. The output of the non-linear filtration 35 stage is a signal, herein referred to as D_{out} , defined as follows:
 $D_{out} = 1$ when the current segment is consistent with the

current state (which can either be an ON state or an OFF state).

Dout =0 when the signal is in transition from the current state to a different state.

5

In a preferred embodiment, the tone detection apparatus includes a cadence processing unit. The cadence processing unit receives the results of the quadrature processing, the precision spectral processing and the logical processing stage. In a 10 preferred embodiment, the cadence processing unit receives from the logical processing unit the binary result of the processing namely the classification result. Alternatively, the cadence processing unit receives the output Dout of the non-linear filtration stage.

15

Cadence Processing

For each tone of interest, the cadence processing stage performs a timing validation test to evaluate whether the timing 20 features of the signal conform to the specification of the tone being considered. Preferably, for each tone of interest, a separate cadence processing unit is present in the cadence processing stage. In a specific example, if it is desired for a tone detector to detect the fax calling tone and the SIT tone then 25 two (2) cadence processing unit will be present in the cadence processing stage namely one for the fax calling tone and one for the SIT tone. Preferably, for each tone, the specifications are stored on a computer readable medium in the tone parameter database 308. Alternatively, each cadence processing unit is configured 30 according to the specifications of their respective tones. In a preferred embodiment, the tone detection apparatus provides a partial confidence feature that reports levels of partial confidence if the full cadence of a tone has not been qualified within a specified time, herein referred to as the observation 35 window.

In a preferred embodiment, the cadence processing stage provides multiple cadence processing units, one for each of the tones of interest. The description below is directed to a single cadence processing unit. Those skilled in the art will readily see 5 how this may be applied to the other cadence processing units.

In a preferred embodiment, the cadence processing operation is performed on the basis of segments. In a preferred embodiment, the cadence processing unit obtains the temporal pattern to be 10 validated from the tone parameter database 308. The cadence processing unit also receives the processed signal from the logical processing unit and may also receive the output of the spectral processing unit. For each pulse in each cadence pattern, the temporal pattern of the tone specifies the state of the signal, the 15 minimum duration and the maximum duration. In a specific example, the OFF states are identified by the digit "0" while the ON states are identified by a vector of digits specifying the desired frequencies. A common tone pattern is an ON-OFF cadence in which the ON pulses are multifrequency tones. In a specific example, 20 such a tone may be specified with the following bit pattern {11, 00, 11} along with an appropriate time duration for each portion of the tone. In another specific example, an SIT tone with three successive signal tones may be specified with the following bit pattern: {001, 010, 100} along with the appropriate length for each 25 segment. In the special case where a tone continues indefinitely, such as the Dial tone, a predetermined value for the maximum duration is set. The specified sequence of NState ON and OFF states, where NState is the number of states in the tone pattern, is considered to be detected with full confidence if the complete 30 sequence of ON and OFF states is detected. The minimum confidence level is also specified as the parameter Minimum_Confidence. The partial confidence levels are also specified in the tone parameters database. In a preferred embodiment, during the transition between two states of the signal, the conditions are relaxed. The length 35 of the transition time is specified by a variable (Transition_Length) in the tone parameter database.

Figure 11 shows flow diagram for the cadence processing block.

In a typical interaction, the system initialises the current state 5 of the pattern to "1" and the current segment count to "0" 1100. Once the system has been initialised, the cadence processing operation begins at step 1102. For each segment, the output of the logical processing unit is processed in the manner described previously. The output of the logical processing unit is such that 10 a "0" signals the transition from the current state to a new state and a "1" indicates that the current segment satisfies the properties of the current state. There is no distinction between ON and OFF states in the cadence processing unit, the distinction having been made in the logical processing stage. The segment 15 counter is then incremented by 1 as step 1102 and condition 1104 is tested. Condition 1104 checks if the system is allowing for a transition. If the number of segments in the transition is less than or equal to the maximum length of the transition, condition 1104 is answered in the positive and the processing of the current 20 segment is complete. If the number of segments in the transition is greater than the maximum length of the transition, then condition 1004 is answered in the negative and the system proceeds to evaluate condition 1108. Condition 1108 evaluates if the signal is in a transition. The presence of a transition is signalled 25 through the presence of $D_{out}=0$. If a transition does not occur, condition 1108 is answered in the negative and the system proceeds to condition 1110. Condition 1110 evaluates the special condition where the tone being tested continues indefinitely (e.g dial tone).

If the tone being tested is not such a tone, condition 1110 is 30 answered in the negative and the cadence processing is done for the present segment 1112. Condition 1110 is answered in the positive if the tone being tested continues indefinitely. In figure 11 this is shown by setting the upper limit of the tone duration to 0 so that only the lower limit is tested. The system then proceeds to 35 condition 1134 in figure 11a. Condition 1134 checks if the number of states is equal to the total number of states (NStates) in the

tone and if the minimum duration of the tone has been satisfied. If either of the conditions fail, condition 1134 is answered in the negative and the cadence processing is done for the present segment 1136. Otherwise, condition 1134 is answered in the positive and the system proceeds to step 1138. At step 1138, the system sets the confidence level to full confidence and then outputs the full confidence result 1140. Following this, the variables are re-initialised 1142. If at condition 1108 a transition is detected, condition 1108 is answered in the positive and condition 1114 is tested. Condition 1114 checks if the current state satisfies the minimum and maximum duration for the tone state pattern. If the duration tolerance is not satisfied, condition 1114 is answered the negative and the system proceeds to step 1116. At step 1116 the state and segment counter are re-initialised and the processing for this segment is complete 1118. If the duration tolerance is satisfied, condition 1114 is answered in the positive and the segment counter is reset to for the next segment 1120. It is then tested at condition 1122 if the number of states is equal to the total number of states in the tone. If condition 1122 is answered in the negative the system proceeds to step 1124 where the state is incremented by 1. The processing is then completed for that segment 1126. If condition 1122 is answered in the positive, the tone pattern has been detected with full confidence. The system sets the confidence level to full confidence 1128 and then outputs the full confidence result 1130. Following this, the variables are re-initialised 1132.

In a preferred embodiment, the cadence processing unit provides a timeout feature. The timeout condition is tested at the sub-frame level. For a subframe that coincides with a segment interval, the timeout conditions are tested after the cadence validation has been performed. Each cadence processing unit in the cadence processing stage must timeout before the cadence processing stage as a whole can report a timeout tone indication. In a preferred embodiment, each cadence processing unit may timeout under the following conditions:

- a) the minimum level of confidence cannot be reached within the remaining time in the observation window. A null confidence level indication is reported.
- b) The full duration of the observation window has been reached. A tone indication is reported with the confidence level equal to the counter of the current state in the cadence processing.

5 In a preferred embodiment, a variable, say "TimeOut", tracks 10 the remaining time before the time in the observation window expires. In a typical interaction, the TimeOut variable is initialised to an observation window value. Preferably, a common observation window value is used for all the cadence processing units in the cadence processing stage. Alternatively, each cadence 15 processing unit is assigned an observation window value independently and the longest observation window value. In this situation the longest observation window duration is used to determine the timeout condition of the entire cadence processing stage. Following this, at the current subframe, a timeout test is 20 performed for each of the selected cadence processing units. The selected cadence processing units are specified in the tone parameter database. The timeout test determined if there is sufficient time remaining in the observation window interval to reach the minimum confidence level state. Mathematically, the 25 condition being tested may be described as follows:

$$(16) \quad TimeOut \geq Subframe\ duration \times step \times \sum_{n=State}^{MinConfidence} Lowlimit[n]$$

where step is the segment advance size in units of subframes.

30 For example, a segment may contain 7 sub-frames while the step may be 5 sub-frames. In this example, successive segments overlap by 2 sub-frames. MinConfidence is the lowest acceptable confidence level and Lowlimit is an array of the minimum durations of the tone state. If inequality 17 is not satisfied, then the cadence

processing unit outputs a signal to indicate it. In a specific example, if inequality 17 is satisfied the cadence processing unit outputs "1" else it outputs "0". Each selected cadence processing unit in the cadence processing stage tests condition 17.

5

When all the outputs indicate that each cadence processing unit has timed out or that the tone detection was not requested, a null confidence tone indication is reported.

10 A specific example will better illustrate the cadence processing operation. The fax calling tone (CNG) is characterised by the following cadence {0.5 sec. ON; 3.0 sec. OFF; 0.5 sec. ON}.

Without the partial confidence feature, a 7.0 second time interval is needed to provide sufficient time to see both ON pulses. This 15 time interval is herein referred to as the observation window of the signal. An alternative is to specify the pattern to be the single 0.5 sec. ON with an observation window of 3.5 sec. However, this method may lead to erroneous detection. Another alternative would be to specify the pattern to be 0.5 sec. ON and 3.0 sec OFF 20 with an observation window of 6.5 sec. However the improvement over the full 7.0 sec. observation window period is minimal.

In a preferred embodiment the cadence processing module of the tone detection apparatus provides a partial confidence feature 25 allowing the cadence unit to report partial confidence measures if the full cadence has not been received. For each tone of interest, a set of levels of confidence are defined. In the specific example of the CNG tone detector, the following levels of confidence are use:

30

Level	Condition
Level 1 (partial confidence)	Single 0.5 sec ON
Level 2 (partial confidence)	0.5 sec ON; 3.0 sec OFF
Full confidence	0.5 sec ON; 3.0 sec OFF; 0.5 sec ON
Observation window	5.0 sec

Other confidence levels and observation window values may be used here without detracting from the spirit of the invention. The levels of confidence for each tone of interest are stored in the tone parameter database 308 of the tone detection apparatus. In 5 a specific example, level 0 confidence indicates that the predefined criteria has not been met. In a preferred embodiment, when a signal has reached a full confidence level, the cadence processing unit outputs it at the time the event occurs. If the full confidence level has not been reached within the observation 10 window period, the partial confidence result is outputted at the end of the observation window period. In the specific example shown previously, the cadence processing unit will report for a valid CNG tone either a level 1, level 2 or full confidence result depending on the alignment of the pulses in the 5.0 sec observation 15 window. For non-CNG tones, there may be cases where a level 1 partial confidence measure is erroneously reported. However, the possibility of error is less than if the pattern had been specified to be the single 0.5 sec ON. The reason is that with the partial confidence feature the detection of a 0.5 sec ON pulse may later 20 be disqualified if the remaining signal does not satisfy the cadence pattern. For example, during the detection of the CNG tone, if a 0.5 sec ON pulse is detected between time 0.5 sec and 1.0 of the observation window, the confidence value is set to level 1. If at time 2.0 sec of the observation window, another ON pulse 25 is observed, the state machine resets the confidence level to 0 and continues to look for the valid pattern in the remaining 3.0 sec of the observation window.

In another preferred embodiment, for each tone of interest, 30 a minimum partial confidence parameter is specified. When it is known that the minimum confidence level cannot be satisfied in the remaining time, the system times out. In other words, the system times out as soon as possible. In a specific example, the minimum confidence level of the CNG tone is specified to be level 2 (0.5 35 sec ON; 3.0 sec OFF) and the observation window is specified to be 7.0 sec. At the time just over 3.5 sec, the cadence processing

unit has not yet seen the start of an ON pulse. Therefore it is not possible for the minimum confidence level to be reached in the remaining < 3.5 sec. The cadence processing unit return a level 0 confidence result after 3.5 sec rather than wait for the full 7.0 5 sec to expire.

In another preferred embodiment of this invention, the tone detection apparatus is integrated into a communication channel, such as one that could be used in a telephone network, that enables 10 the accurate detection and decoding of Multi-Frequency (MF) tones. MF tones are mainly used to transmit calling and/or caller number information between telephone switches. An MF tone is detected if and only if two of the allowable frequencies are above a certain 15 amplitude threshold and the durations are long enough to avoid any erroneous recognition. Each combination of two frequencies represents a pulse that in turn represents a digit. If more than two frequencies are present, as caused by a double key press, the receiver should report an error. Frequency and duration standards for MF are shown in tables 1 and 2.

20

Table 1: The table below shows the multi-frequency (MF) tone combinations for the various digits and control signals.

f1/f2 Hz	700	900	1100	1300	1500	1700
700	X	1	2	4	7	ST3P
900	1	X	3	5	8	STP
1100	2	3	X	6	9	KP
1300	4	5	6	X	0	ST2P
1500	7	8	9	0	X	ST
1700	ST3P	STP	KP	ST2P	ST	X

25

Table 2: Specifications for tone receivers describe a variety of criteria that the receiver should conform to. Tolerances are generally specified with an "accept band", within which the tone should be accepted, and a "reject band" in which the tone should

be rejected. Often there is a gap between these two bands in which the tone may or may not be accepted. The table below shows the tolerance of the MF system as directed by the BellCore specification "BOC Notes on the LEC Networks SR-TSV-002275":

5

	Accept	Reject
Frequency Tolerance	+1.5% + 5Hz, -1.5% -5Hz	± 3.5%
Amplitude Level	0 to -25dBm0 per frequency	≤35 dBm0 per frequency
Amplitude Twist	± 6.0dB. Desirable to accept greater twist	Not specified
SNR Gaussian noise	≥ 20 dB	N/A
Impulse noise	≥ -12 dB	N/A
Tone duration a) of each frequency component	All except KP : ≥ 30ms KP: ≥55ms	All except KP <10ms (desirable) KP : < 30ms
Tone Duration b) Coincidence (overlap)	≥ 26ms (i.e. the two component may be shifted by 4ms)	10ms
Inter-digit duration	≥25ms	Bridge interruptions at least up to 10ms but not exceeding 25ms after the minimum duration signal 30ms has been received

In a typical interaction, a transmitter from a calling office initiates a tone sequence by sending a special tone, called the KP tone, and then proceeds by sending a series tones representing a 10 digit sequence. Upon termination, the transmitter sends a ST tone to indicate the end of the tone sequence. The MF receiver monitors the communication channel for the KP tone. Until its reception, it ignores all signals on the channel. Once it receives the KP tone, it monitors the channel, performs an analog to digital 15 conversion of the signal and proceeds in the spectral and temporal analysis of the signal. The spectral analysis is performed by computing the straight DFT at the six frequencies of interest {700, 900, 1100, 1300, 1500, and 1700} over a short time sub-frame. Following this, a second DFT is performed on the results of the 20 first DFT over a segment. This allows a very high time resolution due to the short time window of the first DFT and a high frequency resolution due to the longer time window resulting from the

concatenation of many sub-frames in the second DFT. Following this computation, the results of the quadrature processing stage and the precision spectral processing stage are sent to the validation unit which evaluates if some predetermined amplitude criteria have been met and if the temporal requirement have been attained. If a valid tone is detected, the corresponding digit is sent to a controller that performs a predetermined operation such as connection or billing. The cadence processing unit may be omitted from the MF receiver without detracting from the spirit of the invention. Once the receiver decodes the ST tone, it stops monitoring the communication channel for digit tone and monitors for the KP tone once again.

In another specific embodiment of this invention, the tone detection apparatus is integrated into a communication channel, such as one that could be used in a telephone network, that enables the accurate detection and decoding of Dual Tone Multi-Frequency (DTMF) tones. DTMF are mainly used for communications between the user and the system and can also be used to transfer information between telephone switches. As a concrete example of DTMF signalling, customers dialling into a service provider and requesting information may confirm what is understood by pressing the numbers on a touch tone pad. DTMF tones are similar to MF tone in the sense that they are composed of two and only two frequencies. However, DTMF tones consist of one frequency from a low group and one frequency from high group and have 16 distinct combinations. The table 3 and 4 show the frequency and time specification for DTMF tones. The spectral processing of a DTMF tone is similar to the MF tones except that the frequencies analysed are different and that there are no KP/ST tones.

Table 3

The table below shows the dual tone multi-frequency (DTMF) tone combinations for the various digits and control signals.

5

		High Group Frequencies (Hz)			
		1209	1336	1477	1633
Low Group Frequencies (Hz)	697	1	2	3	A
	770	4	5	6	B
	852	7	8	9	C
	941	*	0	#	D

Table 4

Tolerances are generally specified with an "accept band" within which the tone should be accepted and a "reject band" in which the tone should be rejected. Often there is a gap between 10 these two bands in which the tone may or may not be accepted. The table below shows the tolerance of the DTMF system as directed by the BellCore specification:

	Accept	Reject
Frequency Tolerance	± 1.5%	± 3.5%
Amplitude Level	0 to -36dBm0 per frequency	<55 dBm0 per frequency
Amplitude Twist	if high frequency tone is 4.0 / -8.0 dB relative to the low frequency tone	Not specified
SNR Gaussian noise	≥ 20 dB each frequency component must satisfy SNR ≥ 16dB	N/A
Impulse noise	≥ -12 dB	N/A
Tone duration	≥ 40ms	< 23ms
Inter-digit duration	≥ 40ms	No rejection bridging specified

From the structural point of view, the tone receiver, in accordance with this invention can be implemented on a digital 5 signal processor (DSP) chip. The present embodiment was implemented using a 56 MHz Motorola 56002 digital signal processor (DSP) written in code able to execute on a 56001 DSP chips and the code is written in assembly language. Alternatively, the above-described method for detecting a tone can be implemented on any 10 suitable computing platform as shown in figure 12. Such computing platform typically includes a real-time CPU 1202 and a memory 1200 connected to the CPU by a data communication bus. The memory 1200 stores the data 1206 and the instructions of the program 1204 implementing the functional blocks depicted in the drawings and 15 described in the specification. That program 1204 operates on the data 1206 in accordance with the algorithms described above to determine if a tone is present in a given signal.

Although the present invention has been described in 20 considerable detail with reference to certain preferred versions thereof, other versions are possible. For example in cases where new signalling must be introduced, it is sufficient to modify the parameters such as frequencies analysed and tolerance in order to use this invention. Therefore, the spirit and scope of the 25 appended claims should not be limited to the description of the preferred embodiment described above.

We claim:

1. An apparatus for performing cadence detection on a signal, said apparatus comprising:
 - 5 - an input for receiving an input signal potentially manifesting a certain cadence;
 - a signal processing functional block coupled to said input for receiving the input signal, said signal processing functional block being operative to successively compute confidence level values over time during a processing period, a currently computed confidence level value being indicative of a likelihood of existence of a certain cadence in the input signal since a beginning of said processing period, said processing period being characterised by a variable duration;
 - 10 - said signal processing functional block including an output for generating an output signal indicative of the confidence level value at the end of said processing period.
- 20 2. An apparatus as defined in claim 1, wherein said signal processing functional block is operative to selectively terminate the processing period on the basis of the currently computed confidence level value.
- 25 3. An apparatus as defined in claim 1, wherein said signal processing functional block is operative to terminate said processing period when the currently computed confidence level value reaches a certain threshold.
- 30 4. An apparatus as defined in claim 1, wherein said signal processing functional block is operative to terminate said processing period when a duration of said processing period exceeds a certain value.

5. An apparatus as defined in claim 4, wherein said signal processing functional block is operative to terminate said processing period when the currently computed confidence level value and an amount of time remaining in the processing period before reaching said certain value indicate that the certain cadence is unlikely to be detected before reaching said certain value.

10. 6. A method for performing cadence detection on a signal, said method comprising the steps of:

- receiving a signal potentially manifesting a certain cadence;
- successively computing confidence level values over time during a processing period, a currently computed confidence level value being indicative of a likelihood of existence of a certain cadence in the input signal since a beginning of said processing period, said processing period being characterised by a variable duration;
- generating an output signal indicative of the confidence level value at the end of said processing period.

20. 7. A method as defined in claim 6, comprising the step of selectively terminating the processing period on the basis of the currently computed confidence level value.

25. 8. A method as defined in claim 6, comprising the step of terminating said processing period when the currently computed confidence level value reaches a certain threshold.

30. 9. A method as defined in claim 6, comprising the step of terminating said processing period when a duration of said processing period exceeds a certain value.

35. 10. A method as defined in claim 9, wherein said signal processing functional block is operative to terminate said processing period when the currently computed confidence level value and an amount of time remaining in the processing period

before reaching said certain value indicate that the certain cadence is unlikely to be detected before reaching said certain value.

5 11. A method for performing cadence detection on a signal, said method comprising the steps of:

- receiving an input signal potentially manifesting a certain cadence;
- processing said signal to successively compute confidence level values over time during a processing period, a currently computed confidence level value being indicative of a likelihood of existence of a certain cadence in the input signal since a beginning of said processing period;
- controlling a duration of said processing period on a basis of the currently computed confidence level value.

10 12. A method as defined in claim 11, comprising the step of terminating the processing period when the currently computed confidence level value reaches a predetermined threshold.

20 13. A method as defined in claim 11, wherein the duration of said processing does not exceed a certain value.

25 14. An apparatus performing cadence detection on a signal, said apparatus comprising:

- an input for receiving an input signal potentially manifesting a certain cadence;
- a signal processing functional block for processing said signal to successively compute confidence level values over time during a processing period, a currently computed confidence level value being indicative of a likelihood of existence of a certain cadence in the input signal since a beginning of said processing period;
- a duration control unit for controlling the duration of said processing period on a basis of the currently computed confidence level value.

15. An apparatus as defined in claim 14, wherein said duration control unit is operative to terminate the processing period when the currently computed confidence level value reaches a 5 predetermined threshold.

16. An apparatus as defined in claim 14, wherein the duration of said processing does not exceed a certain value.

10 17. A tone detection apparatus suitable for detection of call progress tones, a call progress tone being characterised by at least one frequency component and a timing behaviour defining a certain cadence, said apparatus comprising:

- an input for receiving an input signal potentially containing a call progress tone, the signal being capable of being divided in a plurality of consecutive sections;
- a spectral processing unit for processing said signal to generate a plurality of sets of data elements, the sets of data elements providing spectral information about respective sections of the input signal;
- a frequency component processing unit coupled to said spectral processing unit for receiving sets of data elements and for processing the sets of data elements to output sets of classification data elements indicating whether a frequency component of a certain call progress tone exists in respective sections of the input signal;
- a cadence processing unit coupled to said frequency component processing unit for receiving and processing sets of classification data elements to compute over time successive confidence level values for the input signal during a processing period encompassing the sections of the input signal that correspond to the sets of classification data elements processed by the cadence processing unit, a currently computed confidence level value being indicative of a likelihood of existence of a certain cadence in the input signal since a beginning of said processing period,

5 said processing period being characterised by a variable duration;

- said cadence processing unit including an output for generating a signal indicative of the confidence level value at the end of said processing period.

18. An apparatus as defined in claim 17, wherein said cadence processing unit is operative to selectively terminate the processing period on the basis of the currently computed 10 confidence level value.

19. An apparatus as defined in claim 17, wherein said cadence processing unit is operative to terminate said processing period when the currently computed confidence level value reaches a 15 certain threshold.

20. An apparatus as defined in claim 17, wherein said cadence processing unit is operative to terminate said processing period when a duration of said processing period exceeds a certain 20 value.

21. An apparatus as defined in claim 20, wherein said signal processing functional block is operative to terminate said processing period when the currently computed confidence level 25 value and an amount of time remaining in the processing period before reaching said certain value indicate that the certain cadence is unlikely to be detected before reaching said certain value.

30 22. A method for performing tone detection suitable for the detection of call progress tones, a call progress tone being characterised by at least one frequency component and a timing behaviour defining a certain cadence, said method comprising the steps of:

35 - receiving an input signal potentially containing a call progress tone, the signal being capable of being divided in

a plurality of consecutive sections;

- processing said signal to generate a plurality of sets of data elements, the sets of data elements providing spectral information about respective sections of the input signal;
- 5 processing the sets of data elements to output sets of classification data elements indicating whether a frequency component of a certain call progress tone exists in respective sections of the input signal;
- processing said sets of classification data elements to 10 compute over time successive confidence level values for the input signal during a processing period encompassing the sections of the input signal that correspond to the sets of classification data elements processed by the cadence processing unit, a currently computed confidence level value being indicative of a likelihood of existence 15 of a certain cadence in the input signal since a beginning of said processing period, said processing period being characterised by a variable duration;
- generating a signal indicative of the confidence level 20 value at the end of said processing period.

23. A method as defined in claim 22, further comprising the step of selectively terminating the processing period on the basis of the currently computed confidence level value.

25 24. A method as defined in claim 22, wherein said terminating step terminates said processing period when the currently computed confidence level value reaches a certain threshold.

30 25. A method as defined in claim 22, wherein said terminating step terminates said processing period when a duration of said processing period exceeds a certain value.

26. A method as defined in claim 25, wherein said terminating 35 step terminates said processing period when the currently computed confidence level value and an amount of time remaining

in the processing period before reaching said certain value indicate that the certain cadence is unlikely to be detected before reaching said certain value.

5 27. A tone detection system for use in a telecommunication network comprising the apparatus defined in claim 1.

28. A tone detection apparatus suitable for detecting call progress tones, a call progress tone being characterised by a sequence of 10 states, said apparatus comprising:

- an input for receiving an input signal potentially containing a call progress tone, the signal being capable of being divided in a plurality of segments;
- a spectral processing unit for processing said signal to generate a plurality of sets of data elements, the sets of data elements providing spectral information about respective segments of the input signal;
- a logical processing unit coupled to said spectral processing unit for receiving and processing the sets of data elements, said logical processing unit being operative to compute over time successive classification elements for respective segments of the input signal, each of the successive classification elements indicating whether the properties of the signal during the time segment match the properties of a certain state of a certain call progress tone;
- said logical processing unit including an output for generating a result signal representative of the classification element computed by said logical processing unit.

30 29. An apparatus as defined in claim 28, wherein said logical processing unit further comprises a non-linear filtration unit, said non-linear filtration unit comprising, an input for receiving successive classification elements, said non-linear

filtration unit being operative to process said successive classification elements in order to produce a result signal, said result signal containing substantially less variation than said successive classification elements.

5

30. An apparatus as defined in claim 29, wherein said non-linear filtration unit is operational to apply a median filtering operation to said successive classification elements.

10 31. A method for detecting call progress tones, a call progress tone being characterised by a sequence of states, said method comprising the steps of:

- receiving an input signal potentially containing a call progress tone, the signal being capable of being divided in a plurality of segments;
- processing said signal to generate a plurality of sets of data elements, the sets of data elements providing spectral information about respective segments of the input signal;
- processing the sets of data elements to compute over time successive classification elements for respective segments of the input signal, each of the successive classification elements indicating whether the properties of the signal during the time segment match the properties of a certain state of a certain call progress tone;
- generating a result signal representative of the classification element computed by said logical processing unit.

25 32. A method as defined in claim 31, further comprising a non-linear filtration step, said non-linear filtration step further comprising the steps of:

- receiving successive classification elements;
- processing said successive classification elements in order to produce a result signal, said result signal containing substantially less variation than said successive classification elements.

33. A method as defined in claim 32, wherein said non-linear filtration step is operational to apply a median filtering operation to said successive classification elements.

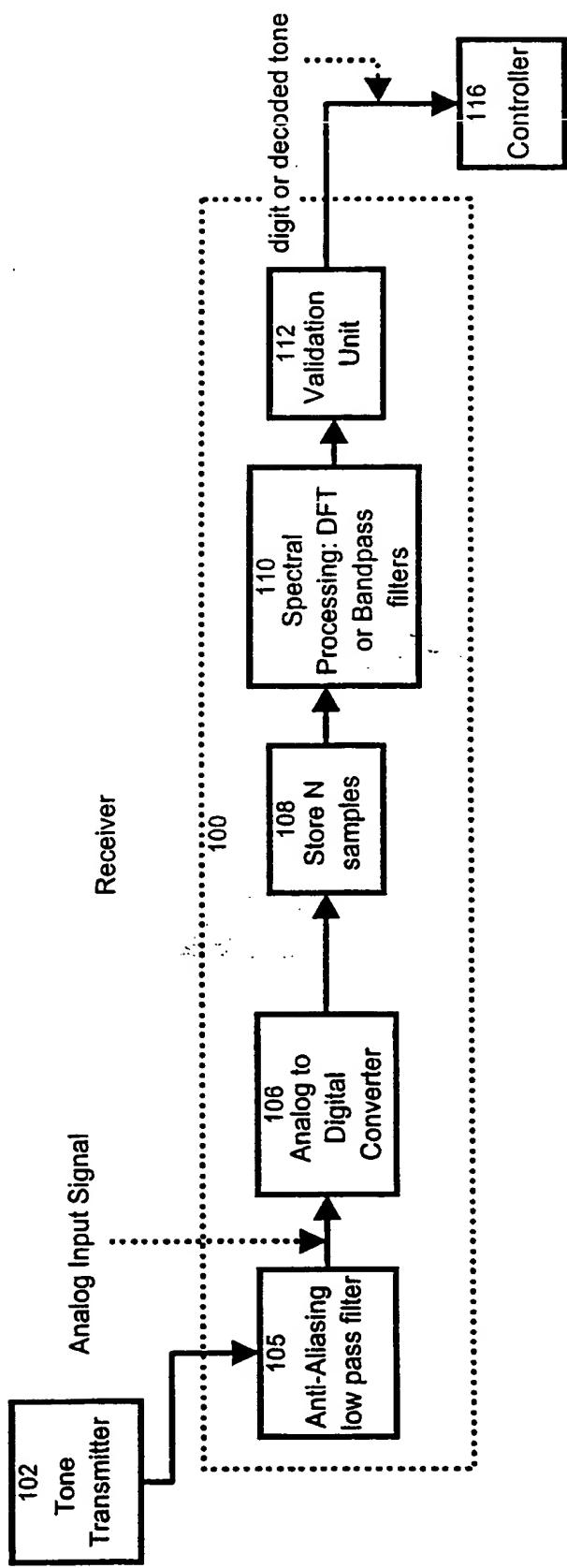


Fig. 1 Prior Art

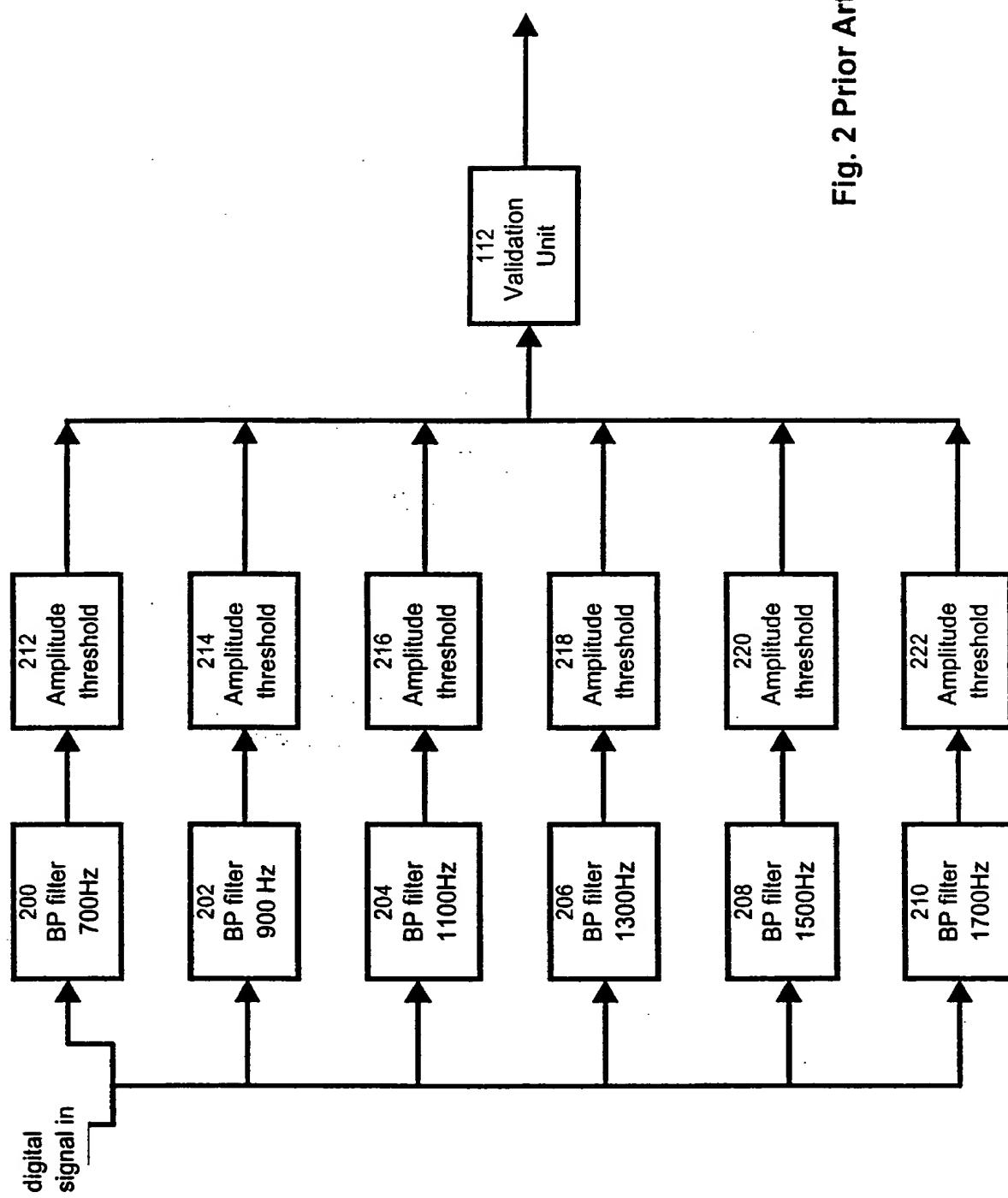


Fig. 2 Prior Art

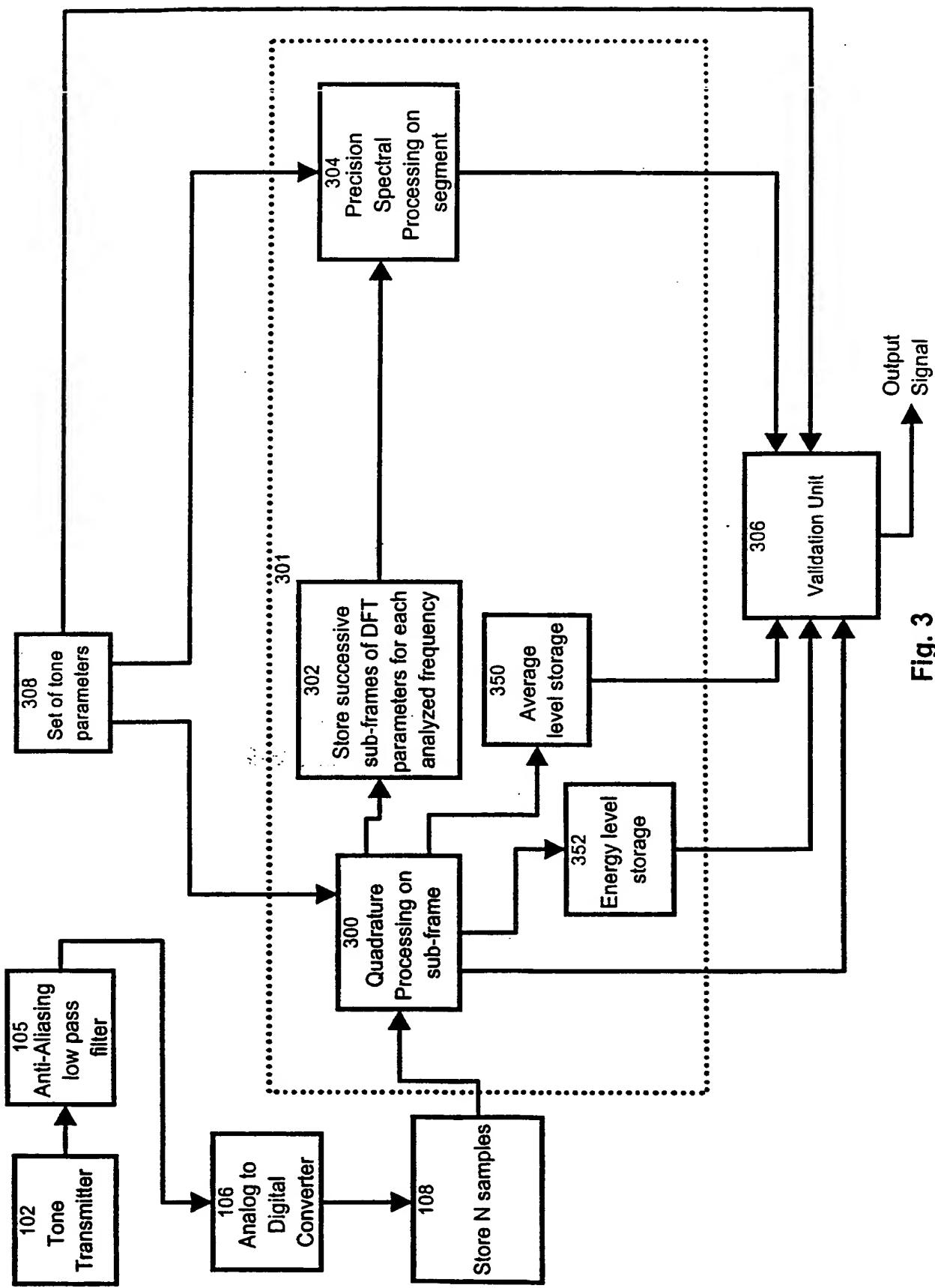


Fig. 3

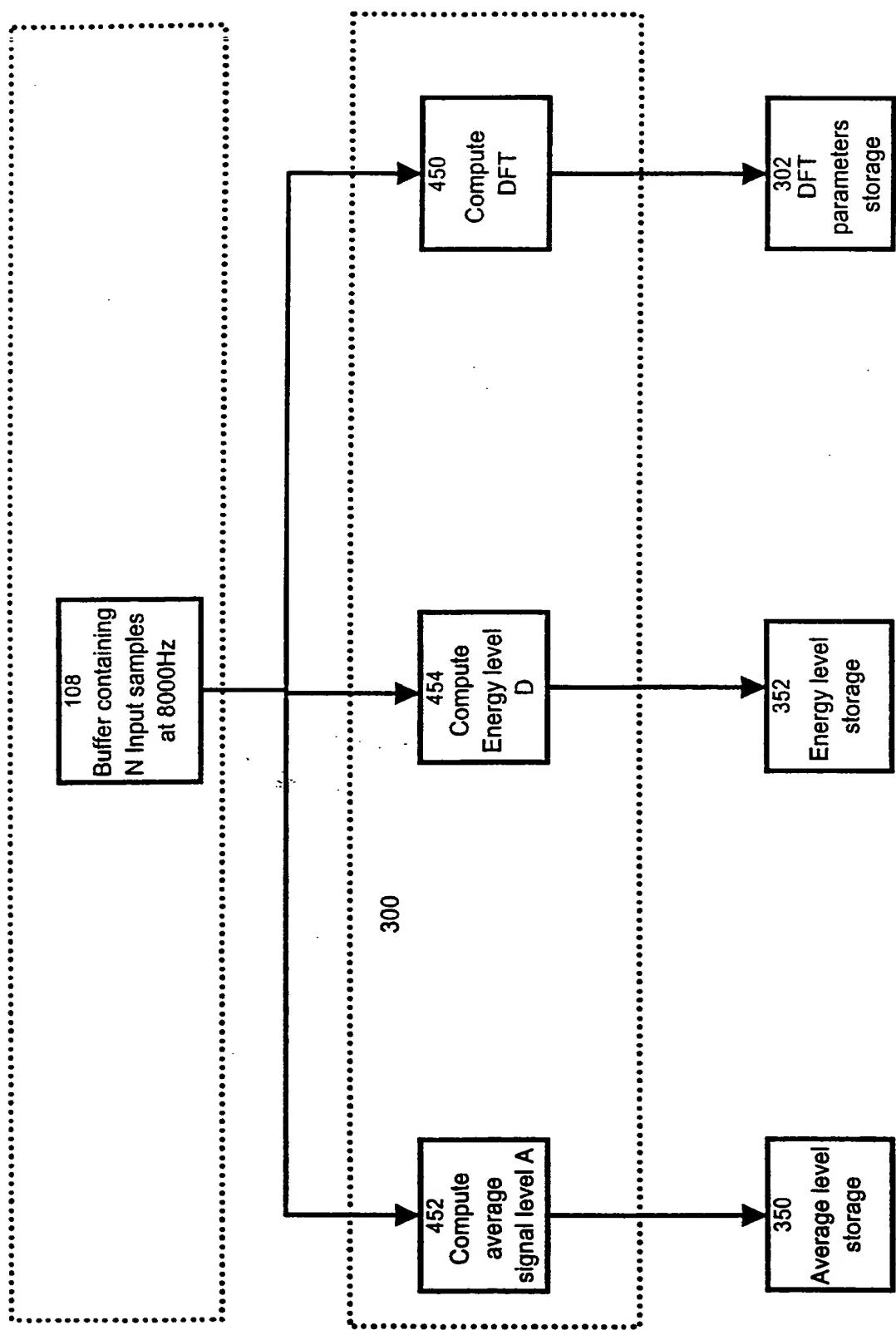


Fig. 4

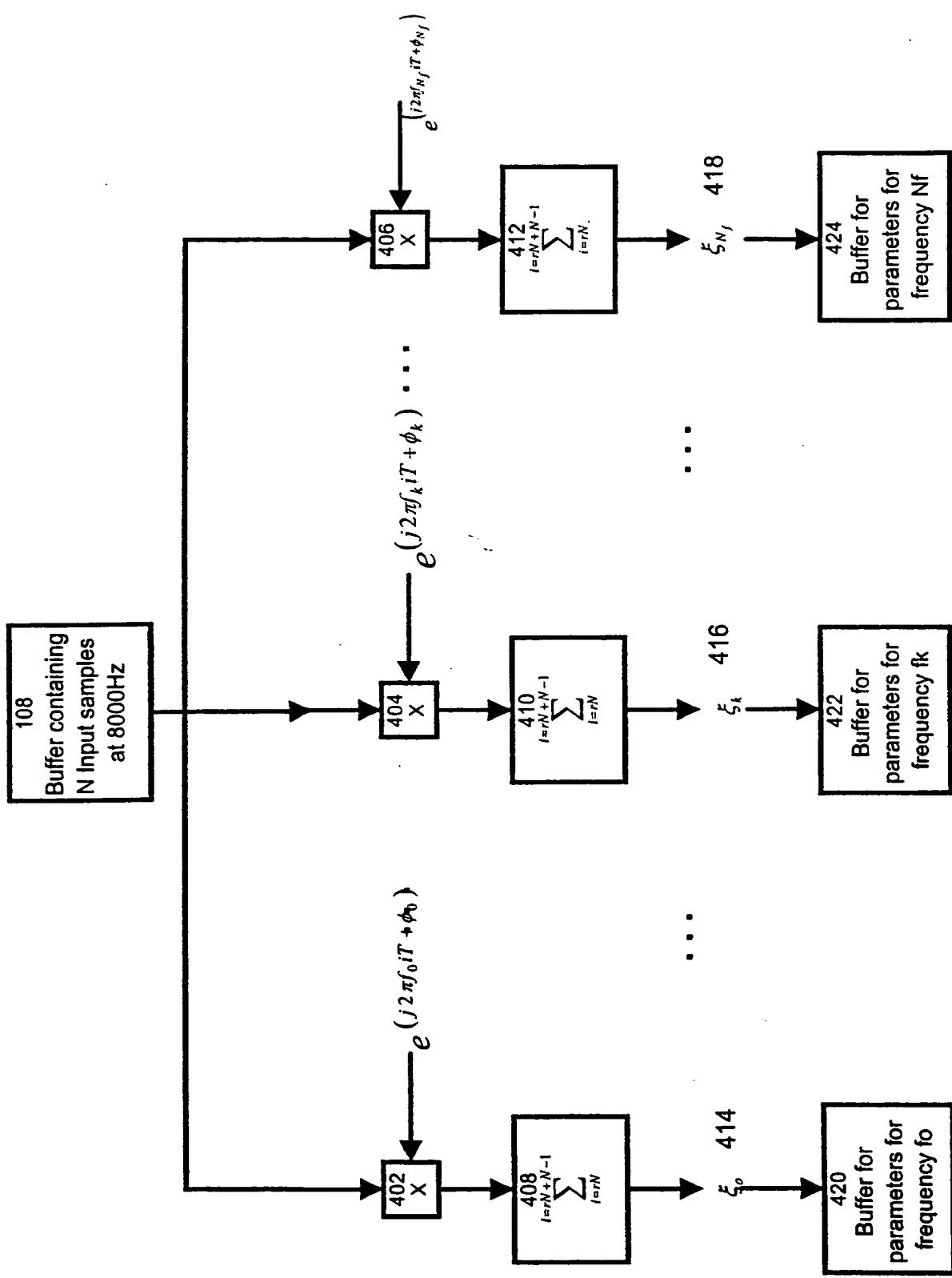


Fig. 5

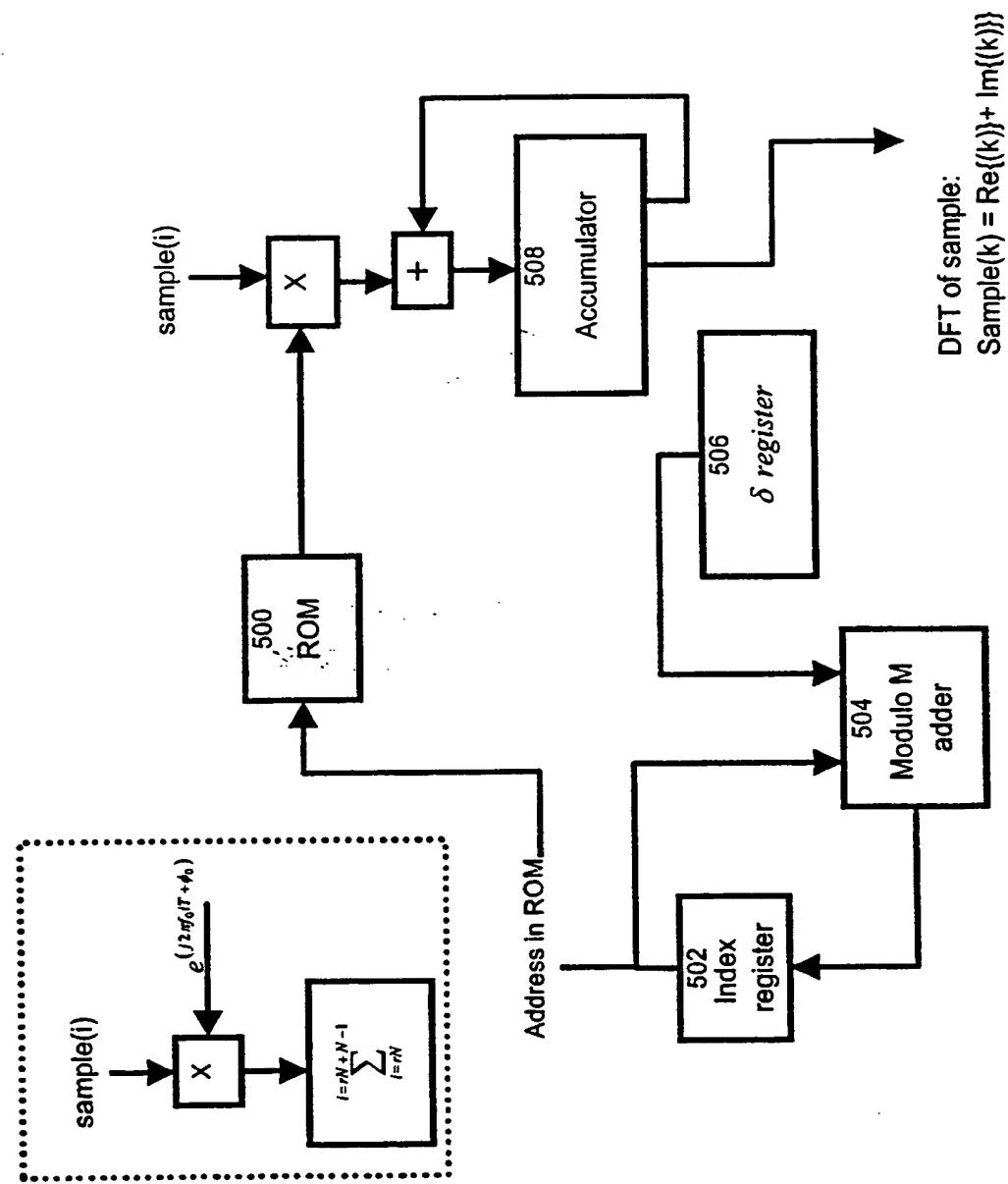


Fig. 6

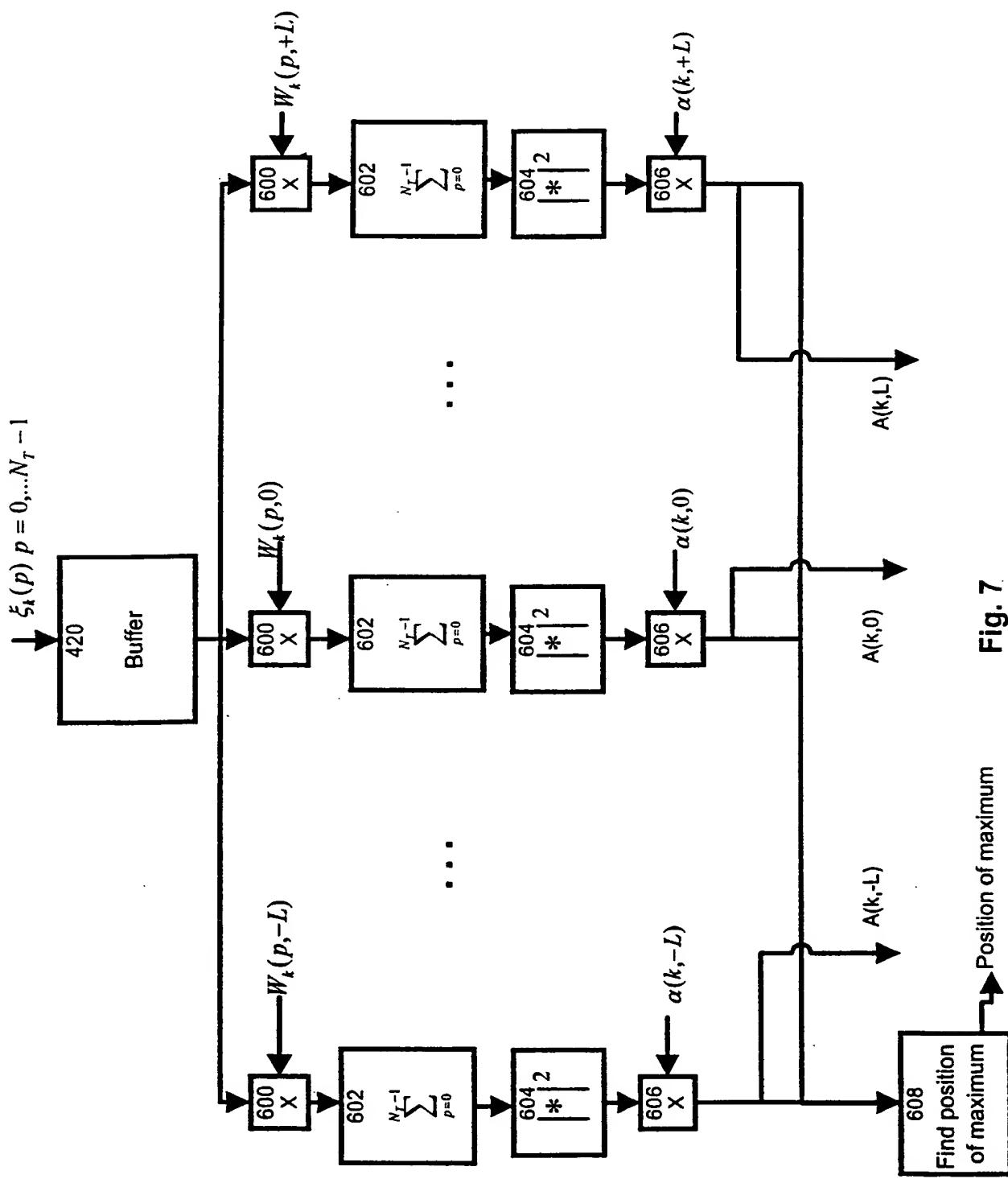


Fig. 7

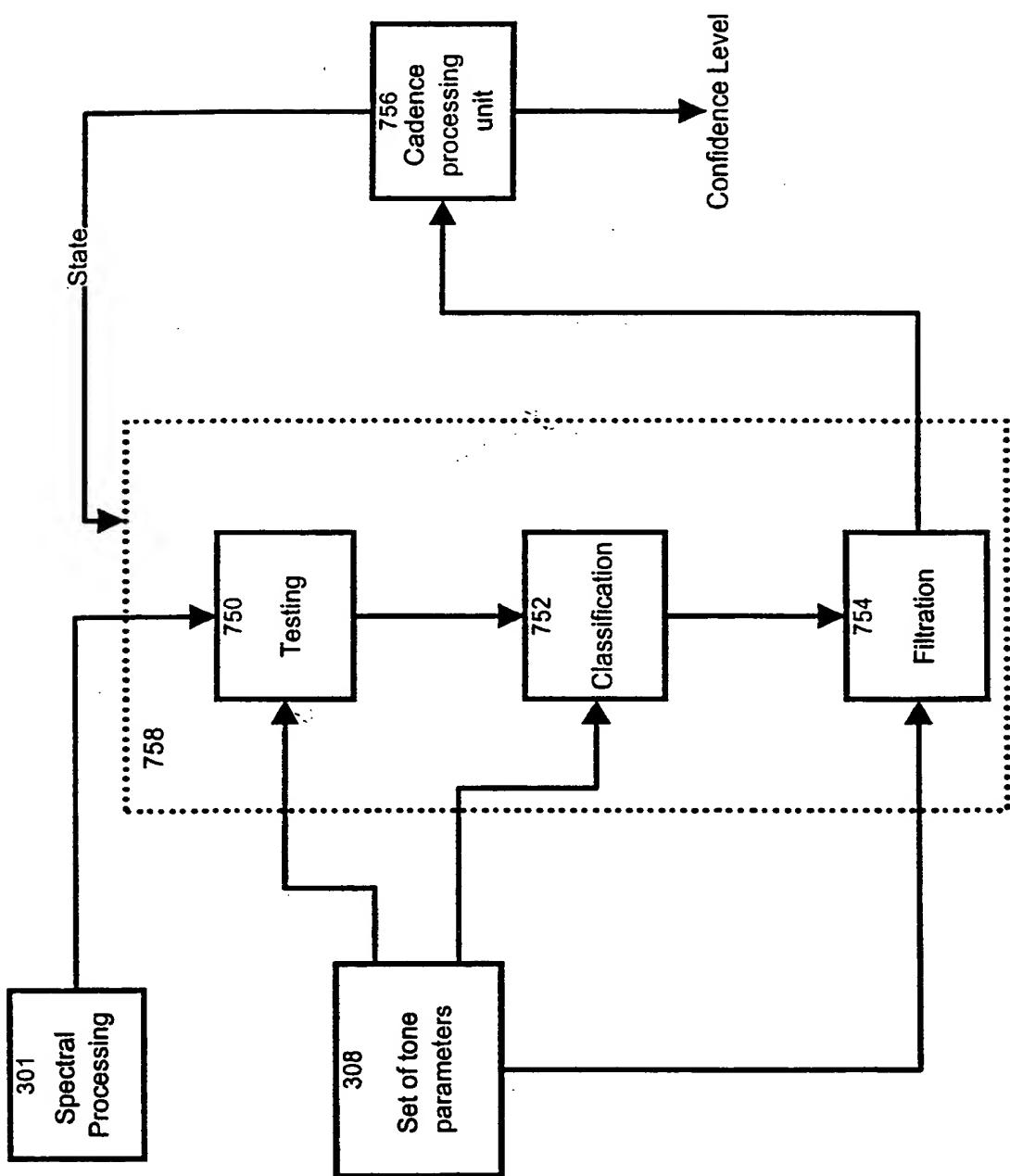


Fig. 8

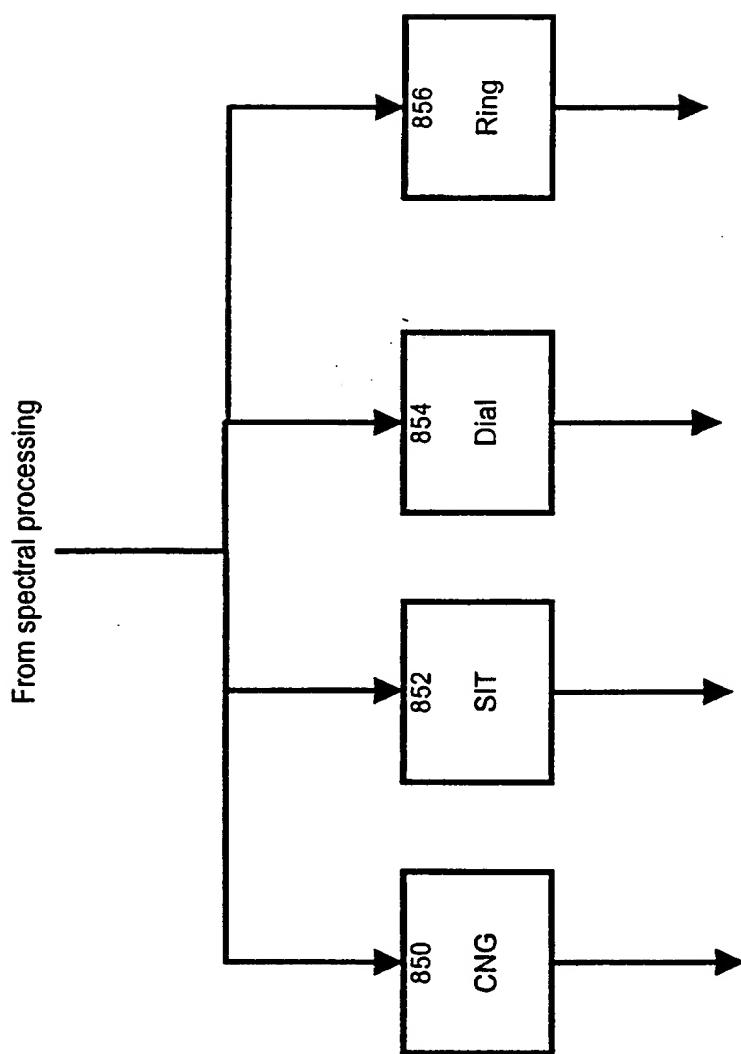


Figure 8a

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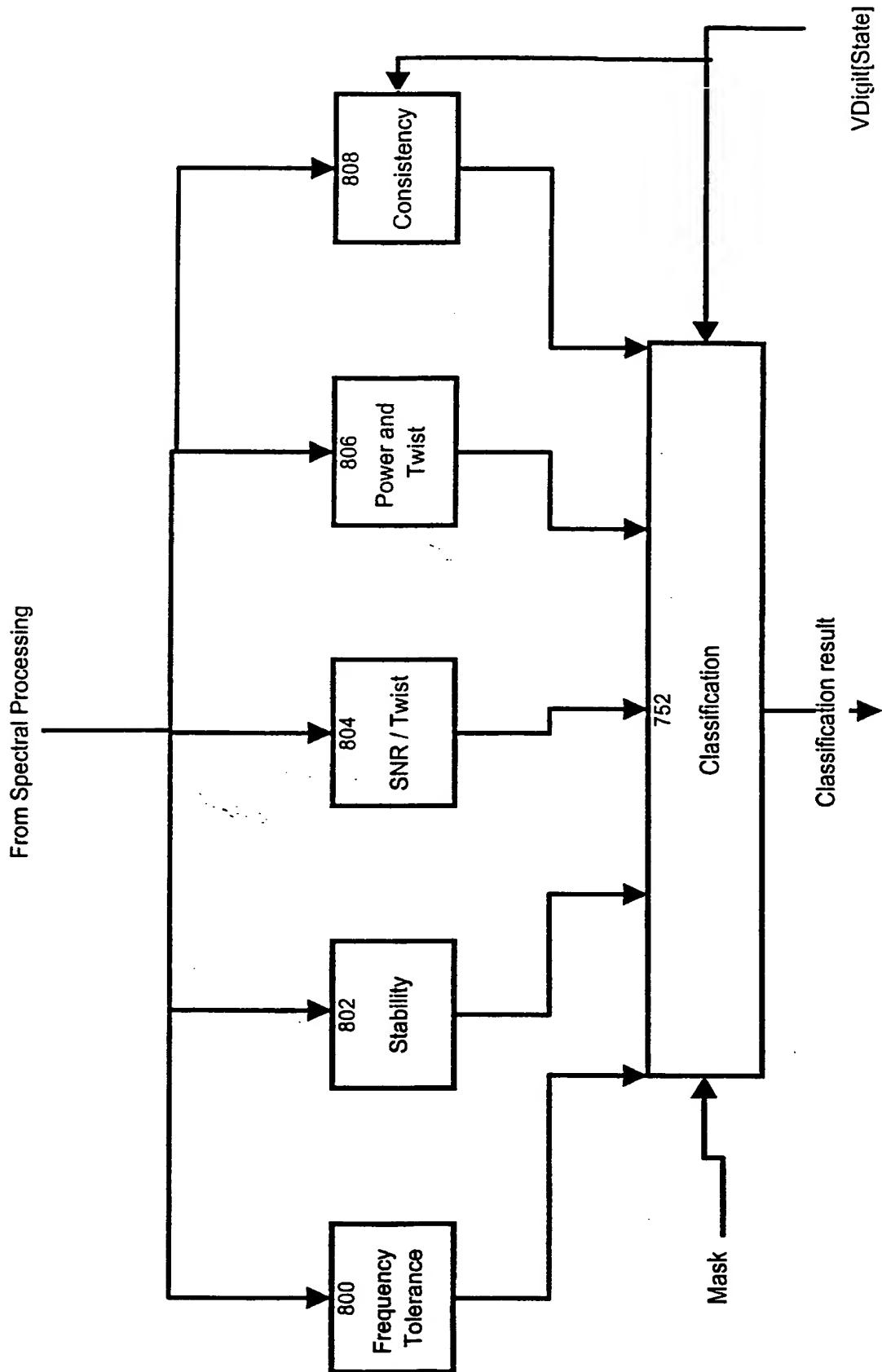


Figure 8b

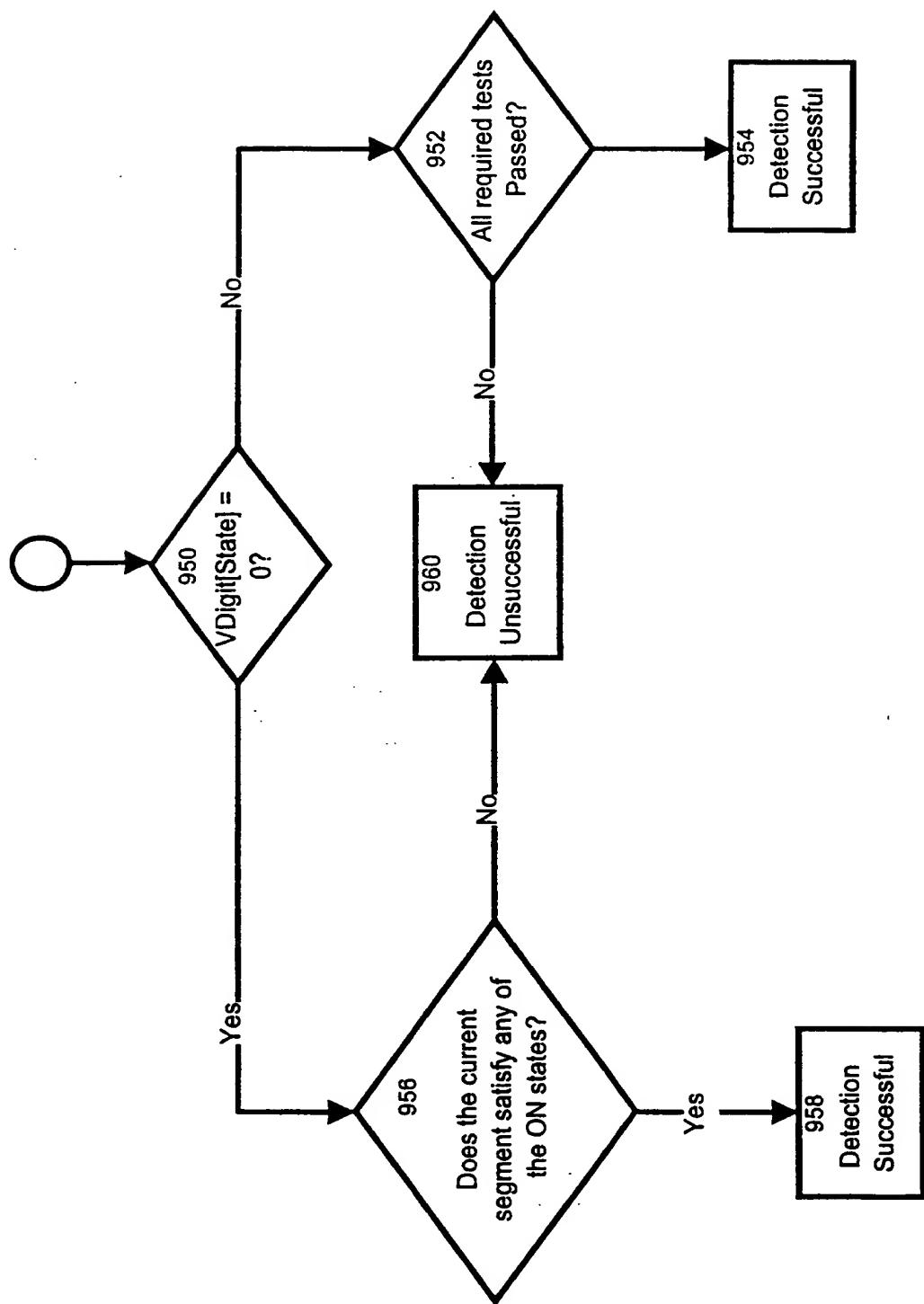


Fig. 9

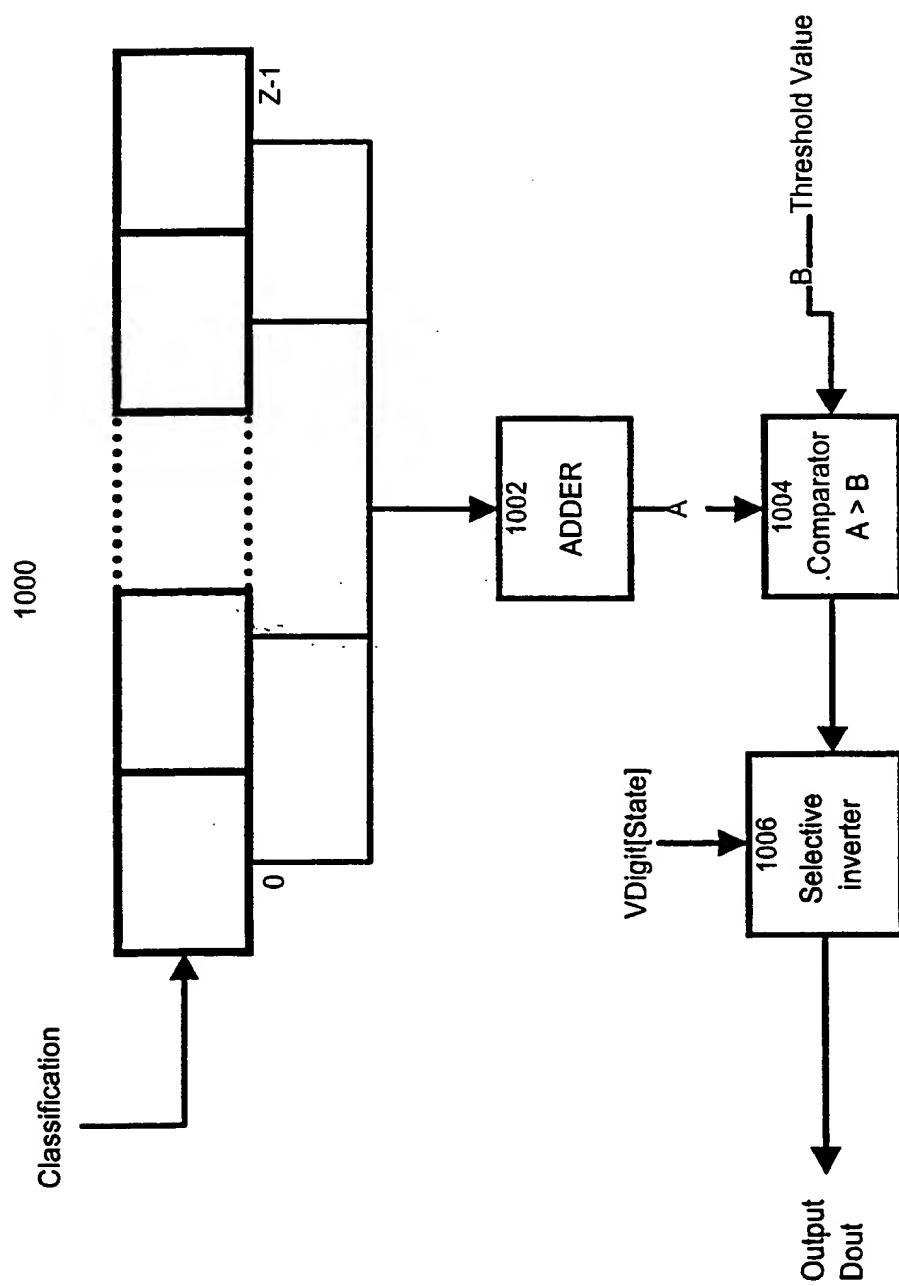


Fig. 10

13/15

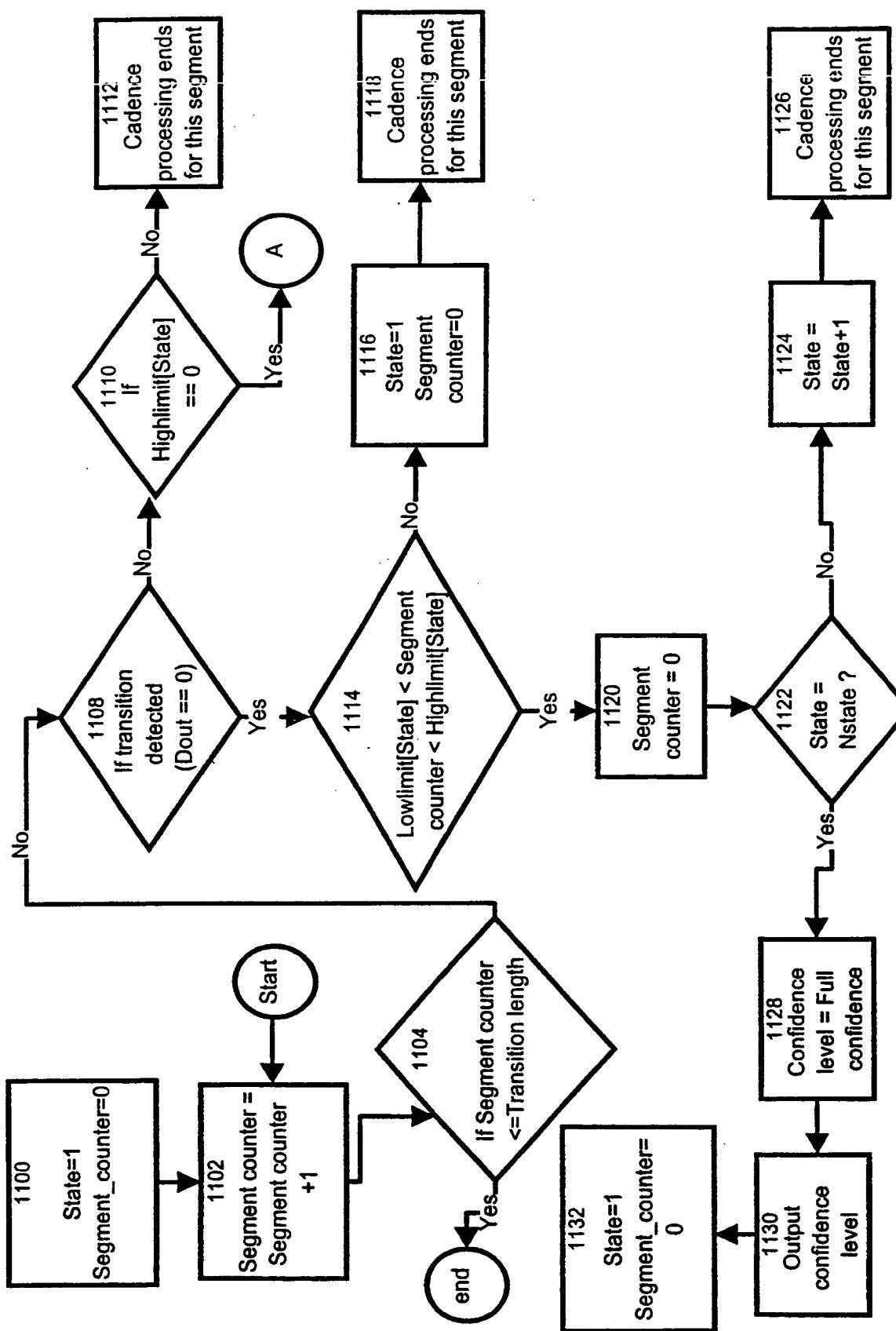


Fig. 11

14/15

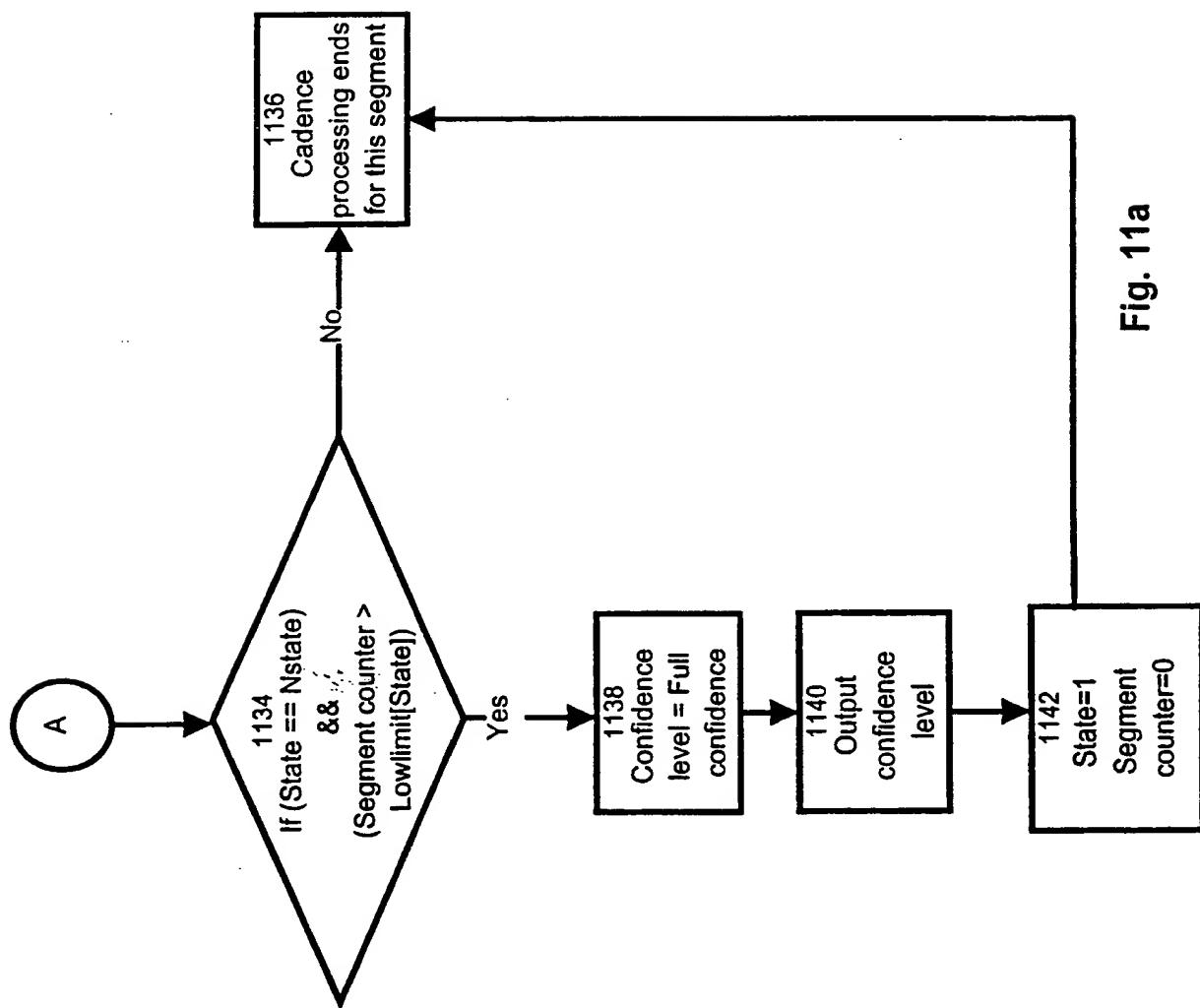


Fig. 11a

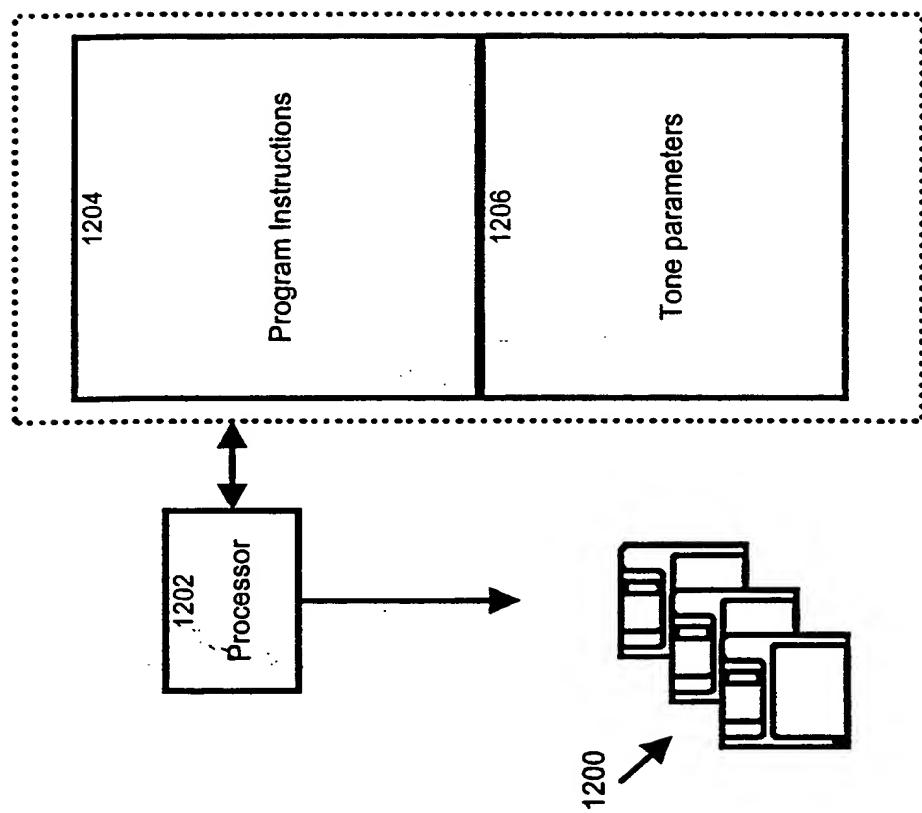


Fig. 12

INTERNATIONAL SEARCH REPORT

International Application No

PCT/RU 98/00353

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 H04M1/00 H04Q1/457 H04Q1/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 IPC 7 H04M H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 550 144 A (AMERICAN TELEPHONE & TELEGRAPH) 7 July 1993 (1993-07-07) page 3, line 3 - line 13 page 5, line 15 - line 17 page 8, line 51 - page 9, line 14 page 12, line 50 page 13, line 32 page 15, line 3 page 15, line 48 ---	1-33
A	US 5 023 906 A (NOVAS ROBERT G) 11 June 1991 (1991-06-11) column 2, line 27 - column 3, line 11 column 8, line 38 - line 40 column 10, line 19 - line 27 --- -/--	1-33

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

*** Special categories of cited documents :**

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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

20 July 1999

28/07/1999

Name and mailing address of the ISA

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 Fax: (+31-70) 340-3016

Authorized officer

Schweitz, M

INTERNATIONAL SEARCH REPORT

International Application No

PCT/RU 98/00353

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 321 745 A (DRORY EATAMAR ET AL) 14 June 1994 (1994-06-14) column 1, line 35 – line 49 column 7, line 39 – line 55 column 12, line 60 – column 13, line 16 -----	1-33
A	US 5 477 465 A (ZHENG BAOHUA) 19 December 1995 (1995-12-19) column 4, line 1 – line 8 -----	1-33

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/RU 98/00353

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